Characterization of Late Cretaceous Volcanic Suites in the TREK Project Area, Central British Columbia (NTS 093F, K)

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Introduction

With the discovery of the large gold resource at the Blackwater deposit of 344 Mt grading 0.74 g/t Au, 5.5 g/t Ag (10 million oz., Christie et al., 2014), volcanic rocks of the associated Kasalka Group have increasingly been recognized as an important exploration target. However, these rocks are not well understood or represented on geological maps as they are poorly exposed over much of the northern Interior Plateau region in central BC. Moreover, they share similar lithological features to older Jurassic and younger Eocene volcanic rocks, making them difficult to confidently identify.

In order to provide increased knowledge about these important rocks, Geoscience BC, in partnership with the Mineral Deposit Research Unit at the University of British Columbia, is undertaking the TREK (**T**argeting **R**esources for **E**xploration and **K**nowledge) project. The TREK project was developed to increase the geological knowledge about controls on mineralization in this important area, and as an initiative to promote exploration in central BC, by combining surficial, bedrock and geophysical data (Clifford and Hart, 2014).

The focus of this research subproject is to characterize the Kasalka Group, and to identify those features that allow for differentiation of Late Cretaceous volcanic rocks from similar looking Jurassic and Eocene volcanic suites in and around the TREK project area. Previous workers have, for example, indicated that the presence of hornblende is a defining feature of Kasalka Group rocks (Anderson et al., 1999). As such, distinguishing stratigraphic and lithological features, textures and mineralogical components in these volcanic rocks is a goal, in addition to providing constraints from geochronology, geochemistry and physical properties. Because the region benefits from excellent aeromagnetic coverage (Aeroquest Airborne Ltd. 2014), the project will also utilize the magnetic characteristics of the various volcanic rock packages.

Keywords: *Kasalka Group, volcanic suites, geochronology, TREK*

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Fieldwork was conducted in the northern half of the TREK project area and also the surrounding area during July and August 2014. Bedrock mapping at the 1:50 000 scale and sample collection were facilitated by logging road and foot access, and concentrated on the area covered by NTS 093F, K map sheets. Field observations and data presented here are primarily from the area south of Vanderhoof, Fraser Lake and Burns Lake and around eastern François Lake (Figure 1). Hand specimens were collected from outcrops for the purpose of geochemical and petrographic analysis. Large rock samples (~20 kg) were collected for geochronology analysis; U-Pb zircon, Ar-Ar hornblende and biotite dating methods will be used on these samples. Selected MINFILE (BC Geological Survey, 2014) locations within the study area were also investigated, and assay samples were taken from these localities.

Previous Work

The wider region benefits from the extensive ongoing regional bedrock mapping as well as the more focused topical studies conducted in the TREK area. The Interior Plateau project, which was initiated in 1992, was conducted under the auspices of the Canada–British Columbia Mineral Development Agreement (1991–1995), and involved geoscientists from the BC Geological Survey and Geological Survey of Canada (Diakow and Levson 1997). More recent regional mapping projects were conducted in the northern part of the TREK area from 1995 to 2000 as part of the Nechako NATMAP project, which was initiated to further improve bedrock and surficial data for central BC (MacIntyre and Struik, 2000). Regional 1:50 000 scale bedrock mapping of the Fawnie and Nechako ranges, now the central area of the TREK project, was conducted between 1992 and 1994 and compiled at the 1:100 000 scale (Diakow and Levson, 1997).

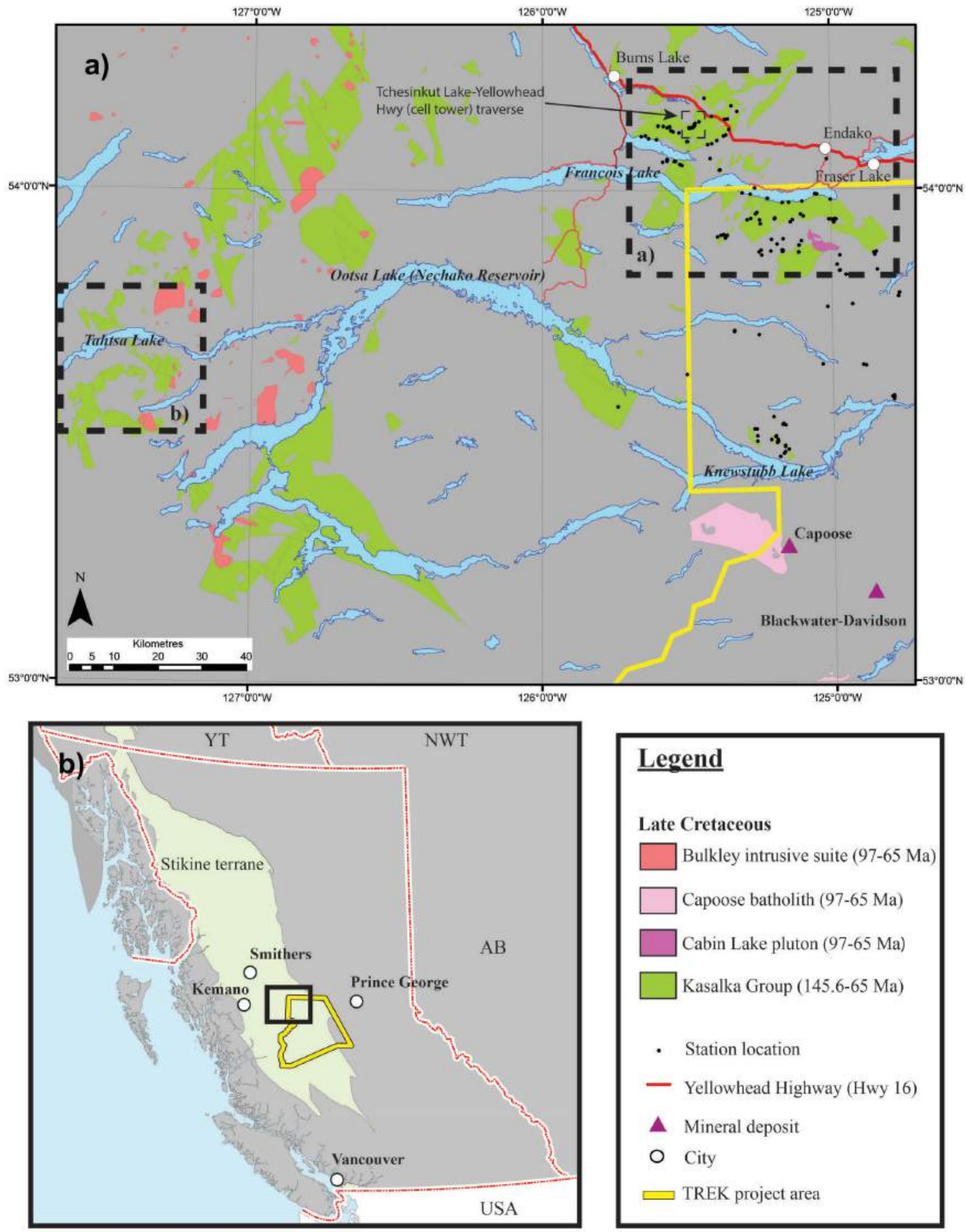

Figure 1. Location map for study area with respect to local communities and the **T**argeting **R**esources for **E**xploration and **K**nowledge (TREK) project area, central British Columbia: **a)** 2014 study area; station localities from field visits are shown as small black dots; **b)** Tahtsa Lake map area, locality for the Kasalka Group type section (MacIntyre, 1977).

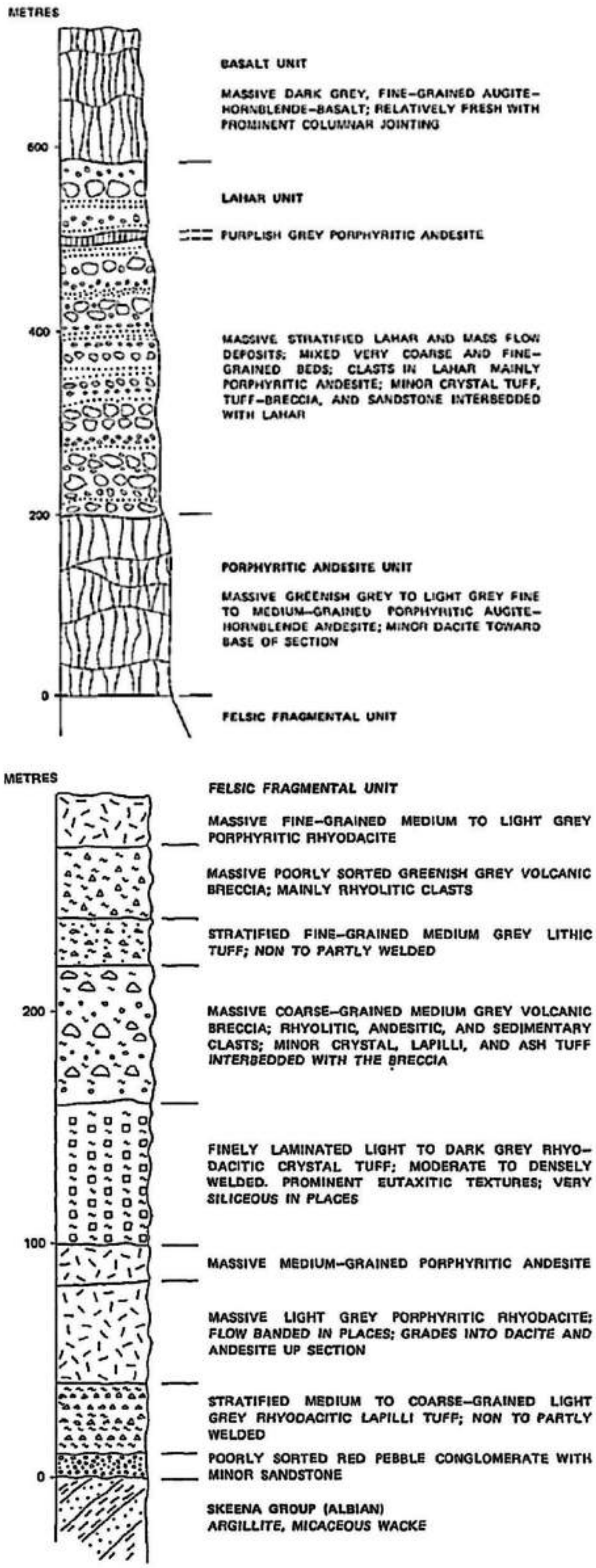

Figure 2. Stratigraphic type section of the Kasalka Group, central British Columbia (from MacIntyre, 1977, 1985).

Regional Geology

Tectonic Framework

British Columbia is dominantly composed of tectonic blocks that were accreted onto the western margin of the ancestral North America continent through the Mesozoic. Much of central BC is underlain by the Intermontane terrane, which is composed of the amalgamated Stikine, Cache Creek and Quesnel terranes (Monger and Price, 2002). The Stikine and Quesnel terranes formed as oceanic island volcanic arcs, with similar compositions and stratigraphy. The two terranes may have been part of the same Late Triassic arc that enclosed the Cache Creek terrane during accretion onto the continental margin (Mihalynuk et al., 1994). The Mesozoic volcano-sedimentary packages of Stikinia form the basement rocks in the study area, and are composed of Late Triassic to Middle Jurassic arc volcanic rocks and their erosional products. Overlapping basinal assemblages of the Bowser Lake Group record marine deposition from Upper Jurassic until the mid-Cretaceous, with subsequent deposition of the Skeena Group in the Early Cretaceous (Riddell, 2011). Postdeformation, continental margin arcs were unconformably deposited episodically during the Late Cretaceous to the Eocene and produced the Kasalka, Ootsa Lake and Endako groups of volcanic strata (Evenchick, 1991). Miocene volcanism produced the Chilcotin flood basalts, which overlie older units (Mathews, 1989).

Kasalka Group

Rocks attributed to the Late Cretaceous Kasalka Group have a wide distribution from Kemano, in coastal BC, and as far north as Smithers, BC. The Kasalka Group was first described by MacIntyre (1977), west of the TREK project area, in the Whitesail Lake map area (NTS 093E) of west-central BC; a generalized stratigraphic section is shown in Figure 2. Previously, these rocks have been interpreted to be either Jurassic andesite or younger Eocene felsic rocks. The Kasalka Group is described to have an angular unconformity of basal conglomerate overlying deformed older rocks. The conglomerate is unconformably overlain by thick packages of andesite flows and volcaniclastic rocks. The youngest members of the Kasalka Group consist of rhyolitic flows that unconformably overlie the andesite and volcanic rocks (MacIntyre, 1977, 1985).

Other volcanic rock units with Late Cretaceous age constraints are variably considered to be equivalent to the Kasalka Group. Most notably, the Tip Top Hill volcanic suite located near Smithers, northwest of the study area, has been interpreted to be part of a similar Late Cretaceous package (Church and Barakso, 1990).

Kasalka Group volcanic rocks host or are directly associated with several mineral deposits, including the large Blackwater epithermal style Au-Ag deposit (Christie, et al., 2014). The Capoose Au-Ag deposit ~100 km south of Fraser Lake is hosted in similar rock types of comparable age (Diakow et al., 1997). The Newton deposit, located ~175 km southeast of the Blackwater deposit, is also hosted in Late Cretaceous felsic fragmental volcanic rocks (McClenaghan, 2013) and likely represents the most southerly occurrence. Lithologically similar rocks also host the Silver Queen epithermal Au-Ag-Zn-Pb deposit (Leitch et al., 1991).

From field observations, contacts between the various Kasalka Group units described across the study area are inferred to follow a generally northwest trend. The map patterns these interpretations are based on are from past British Columbia Geological Survey (BCGS) publications of the region. Field observations incorporated with data from previous studies are included in the following descriptions of stratigraphic units of the Kasalka Group.

Conglomerate

The conglomerate is composed of a polymictic, poorly sorted, boulder-to-cobble, clast-supported package (Figure 3a). Exposures are found north and south of François Lake and trend northwest over approximately 28 km. Outcrops have an overall low profile, with greater topographic relief observed toward the northwest. This unit is readily identified by the weathering contrast between the clasts and matrix. Cobble-sized clasts (5–10 cm diameter) are well rounded, with the majority of clasts consisting of fine-grained green and maroon volcanic suites and flow-banded rhyolite. Less common are pebble-sized clasts (0.5–5 cm diameter) of black to dark grey chert and siltstone, granite to granodiorite/monzonite, and polymictic pebble conglomerate.

Two matrix compositions are observed in the conglomerate. The first is volcanic in origin, similar in composition to the green and maroon clasts. The second type is sedimentary, dominantly dark red quartz-feldspar sand matrix (MacIntyre, 1977) with green-grey silica. At one locality a dark red quartz-feldspar sandstone lens is found to be interleaved within the conglomerate. This sandstone is the same composition as the sedimentary matrix. The conglomerate is described as forming the base of the Kasalka Group, which unconformably overlies the Jurassic Hazelton and Middle Cretaceous Skeena groups (Leitch et al., 1991; Diakow et al., 1997). Contacts with other units were not observed; however, outcrops are located stratigraphically and topographically lower than andesite and rhyolite outcrops. Detrital zircon ages will further constrain the ages of this unit.

Andesite Flows

Andesite flows are the largest unit of the Kasalka Group, and unconformably overlie the basal conglomerate (MacIntyre, 1977). Outcrops are found along a similar north-northwest trend from Burns Lake to Knewstubb Lake, a distance of ~83 km. The andesite to dacite flows are similar in appearance to U-Pb and K-Ar dated Late Cretaceous samples (Friedman et al., 2001). The weathering profile ranges from pale grey-brown to grey-purple. The fresh surfaces of these andesite flows are variable, generally green or grey to maroon/purple (Figure 3b). The plagioclase and hornblende phenocrysts (overall 10–20% each, 1–3 mm in length) are ubiquitous, and can give the unit a porphyritic texture.

The andesite flows are largely coherent, but fragmental assemblages are also observed where segments of the flow are suspended in a matrix of the same andesite flow. The uniformity of these fragmented sections suggests they are either volcanic debris or reworked sections of these flows (MacIntyre, 1977).

Rhyolite

Outcrops of rhyolitic ash to crystal tuff of the Kasalka Group are located south of the eastern half of François Lake, within the François Lake Provincial Park. This unit consists of whitish-pink to grey weathering surfaces, on low profile outcrops and rubble piles. Fresh surfaces are light pink-grey to bright pink, with a fine-grained matrix, and chalky green lithic fragments of altered green pumice (0.3–2 cm) making up ~15% of the unit (Figure 3c).

Tchesinkut Lake–Yellowhead Highway (Cell Tower) Traverse

A traverse was carried out approximately 8 km southeast of the town of Burns Lake (Figure 1), along a forest service road (accessible from the Yellowhead Highway) that leads to a radio reception tower. Along this road there are a number of outcrops that show a stratigraphic succession moving uphill. This traverse consists of a relatively undeformed, subhorizontal to gently northwest-dipping succession of units, beginning with a basal conglomerate that is subsequently overlain by andesite and rhyolite flows, and lahar deposits. The succession is capped by dark black basalt that is lithologically similar to the Chilcotin Group. Given that the stratigraphy is intact, this traverse crosses through at the lowermost stratigraphy of the Kasalka Group. A plagioclase dacite sample previously taken for geochronology near the tower location returned an igneous crystallization age of 74.2 ±0.3 Ma (Grainger, 2000). Lithological similarities from these outcrops can be correlated to the Kasalka Group type section described by MacIntyre (1985) and shown in Figure 2.

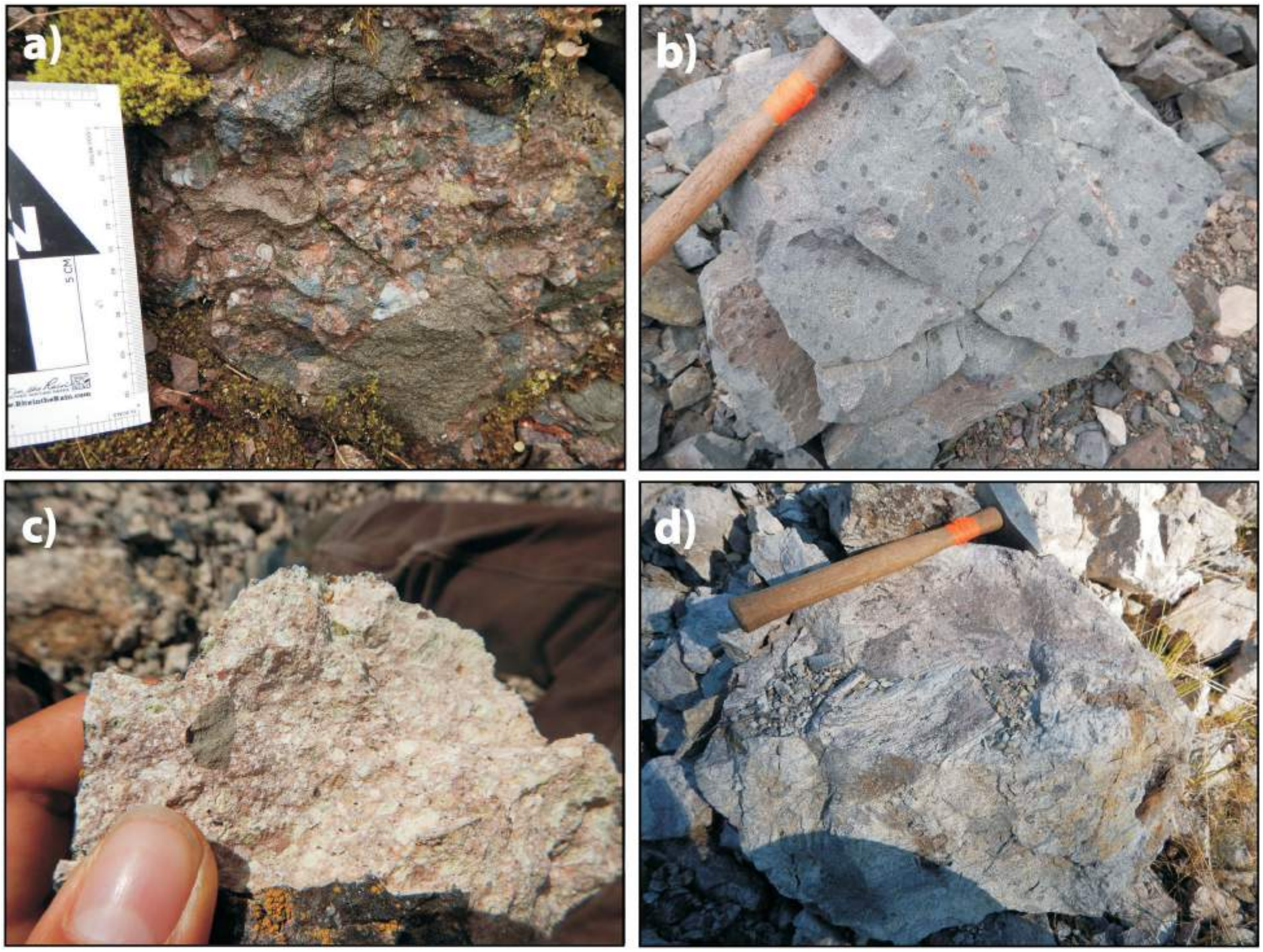

Figure 3. Kasalka(?) Group members, central British Columbia: **a)** basal conglomerate; **b)** andesite flows; **c)** pink rhyolite tuff with altered pumice clasts; **d)** flow-banded rhyolite.

Previous Geochronology

Previous geochronological studies of Cretaceous and Jurassic rocks were conducted in conjunction with the Nechako National Geoscience Mapping Program (NATMAP) project (Friedman et al., 2001; Grainger et al., 2001). These studies were constrained to the Ootsa Lake, western François Lake and Fawnie Range areas. Rocks from the Blackwater-Davidson deposit returned ca. 70 Ma mineralization ages (K-Ar whole rock), which are similar to those from the Capoose prospect and suggest that mineralization was Late Cretaceous and related to continental-arc magmatism (Friedman et al., 2001). Late Cretaceous U-Pb dates (75–67 Ma; 72–70 Ma) were more recently reported near Ootsa Lake and François Lake (Ferbey and Diakow, 2012) on rocks previously mapped as Eocene. At the Blackwater-Davidson deposit, U-Pb ages between 74 and 72 Ma are reported for the host Kasalka Group (Christie et al., 2014). At the Silver Queen deposit, 75 km northeast of Tahtsa Lake, the Kasalka Group rocks returned K-Ar whole rock ages from 105 Ma to 78 Ma (Leitch et al., 1991). The Newton deposit in the Chilcotin Plateau is also hosted in similar Late Cretaceous rocks with U-Pb ages between 72 and 70 Ma (McClenaghan, 2013).

Discussion

The characteristics of volcanic rocks and suites in the northern TREK project area that are presented herein were documented by field observations. Geochemical, petrographic and geochronological analysis will be used to understand similarities and differences between these similar-looking units of Eocene, Cretaceous and Jurassic age. Late Cretaceous Kasalka Group rocks have been found proximal to, and hosting, the Blackwater-Davidson deposit and Capoose prospect (Friedman et al., 2001; Diakow, 2012 and Christie et al., 2014). Exposures of Kasalka Group rocks near Ootsa and François Lake (Ferbey and Diakow, 2012) have been dated using U-Pb geochronology; however, the distribution of these Late Cretaceous rocks in the TREK area is otherwise poorly constrained due to the lack of defining characteristics to distinguish them from other volcanic packages. Kasalka Group exposures are interpreted dominantly as andesite to rhyolite, with sparse basal conglomerate exposures.

The stratigraphic succession at the Tchesinkut Lake radio tower from this study utilizes the Kasalka Group type-sections developed by MacIntyre (1985). Compared to the type-section, the radio tower traverse consists of the lower and uppermost portions of the type-section, similar to those described at Mont Baptiste (MacIntyre, 1985). A large portion of the type-section is composed of rhyodacite, lahar deposits and volcanic breccia, and was not observed along this traverse. In other parts of the study area, rhyodacite and rhyolitic volcanic breccia units are observed, but with little stratigraphic context.

The presence of hornblende phenocrysts was suggested by Anderson et al. (1999) as a common feature in Late Cretaceous fragmental volcanic rocks of the Knapp Lake area, 20 km south of François Lake. Hornblende phenocrysts were observed in this study, mainly in the andesitic volcanic rocks and intrusive suites and as such, are tentatively interpreted to be Late Cretaceous. However, the presence of hornblende phenocrysts is not pervasive across previously mapped Kasalka Group rocks, and as such this mineral may not be entirely reliable as a distinguishing feature. Hornblende phenocrysts also appear as components in the late Jurassic Bowser Lake Group (Nechako) volcanic rocks (Diakow et al., 1997) and are lithologically difficult to differentiate from Kasalka Group volcanic rocks. Evaluation of these rock types and hornblende phenocrysts by petrographic and geochemical methods may provide further constraints on the characteristics of the Kasalka Group volcanic rocks.

Furthermore, the age distribution of the Kasalka Group is broad and variable. Reported ages ranging from 105 to 75 Ma (MacIntyre, 1988) suggest that the Kasalka Group ranges from mid to latest Cretaceous in age, while Late Cretaceous ages have been reported for rocks that were previously mapped as Jurassic and Eocene (Friedman et al., 2001). Improved lithological and age constraints on the Late Cretaceous volcanic suites will provide improved regional context and discriminate potential regions that may be more prospective for precious-metal mineralization. Further work will include detailed characterization of samples using geochronology, petrology and geochemical analyses. Correlations between geochemical and petrographic observations will be made in order to determine characterizing features at the macro and microscopic scales. The age and stratigraphy of the Kasalka Group units will also be constrained with U-Pb and Ar-Ar dating.

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