# Geology of the Greenwood Map Area (NTS 082E/02), Boundary District, Southern British Columbia

**T. Höy, consultant, Sooke, BC, thoy@shaw.ca**

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## Introduction

Geological mapping and compilation of the Greenwood map area in the Boundary district of southern British Columbia (BC) is a continuation of work completed in the eastern half of the Penticton map area (NTS 082E). Five 1:50 000 NTS maps have been published, as shown in Figure 1, and the Greenwood map (NTS 082E/02) will be released in 2018. The project is focused mainly on the potential and controls of Paleogene and older base- and precious-metal mineralization. Compilation of the eastern part of the Penticton map area, including correlation of all units and a standardized nomenclature, will also be completed in 2018. The project includes radiometric dating of intrusive and volcanic rocks throughout the area, done in conjunction with The University of British Columbia, that will better constrain magmatic and coeval mineral and tectonic events.

## Geological Setting

The location and geological setting of the Greenwood map area is shown in Figure 1. The exhumed Grand Forks complex occurs immediately to the east, bounded by the extensional Kettle River and Granby faults. The northern extension of the Toroda graben occurs in the western part of the area (Tempelman-Kluit, 1989). The grabens, bounded by high-angle normal faults that record a complex history of extension throughout the Paleogene, are filled by a thick succession of dominantly alkalic volcanic rocks of the Penticton Group, in part as remnants of more extensive volcanism and in part controlled by marginal growth faults. Large exposures of dominantly syenite of the middle Eocene Coryell intrusions occur to the north and extend into the northeastern part of the Greenwood map area.

The distribution of base- and precious-metal mineralization in the Penticton map area, and farther east to the Slocan camp, is controlled in part by the north-trending extensional faults that bound the core complexes. These faults expose higher structural levels in their hangingwall, an environment more conducive to mineralization as seen in the Franklin mining camp, but also locally may cause deposition of Eocene-age mineralization as in the Slocan camp (Höy, 2013).

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## Local Geology

A simplified geological map of the Greenwood area is shown in Figure 2, in large part modified from regional mapping by Little (1983), Fyles (1990) and Massey (2007a), as well as more detailed mapping in the Greenwood mining camp by Church (1986). Mapping this past field season concentrated north and east of the work by Fyles (1990) and Massey (2007a), mainly in an attempt to tie together lithological units and structures across map boundaries and to bridge geological mapping to the north in the Almond Mountain map area (NTS 082E/07; Höy and Jackaman, 2016) with that of Little (1983). As well, an attempt is being made to more closely constrain the age of intrusive and volcanic rocks by radiometric dating, which is being done at The University of British Columbia.

The oldest layered rocks within the area, the Knob Hill Group, have been described in considerable detail by Fyles (1990). Massey (2006) informally changed the name to the Knob Hill complex, a term that is retained in this paper as it reflects the inclusion of intrusive units with layered volcanic and sedimentary rocks. The complex is poorly dated: a single macrofossil of Carboniferous or Permian age was reported by Little (1983) but Late Devonian conodonts were obtained from the same limestone bed by Orchard (1993). Exposures of gabbro, referred to as the ‘Old Diorite’ by Church (1986) intrude the complex south and east of Greenwood (Figure 2) and serpentinites in the complex form tectonically emplaced lenticular bodies along thrust faults (Fyles, 1990; Massey, 2007b). Several areas of paragneiss (Pkgn) are included with the Knob Hill complex, a correlation that was supported by Church (1986), Fyles (1990) and Massey (2007a).

The Attwood Group comprises mainly deformed metasedimentary rocks that have yielded macrofossils and conodonts of Mississippian to Permian age (Little, 1983; Church, 1986; Orchard, 1993). Their relationship to the Knob Hill complex is not known because there are no recognized stratigraphic contacts between the units. Massey (2007b) suggested that the Paleozoic rocks south of Rock

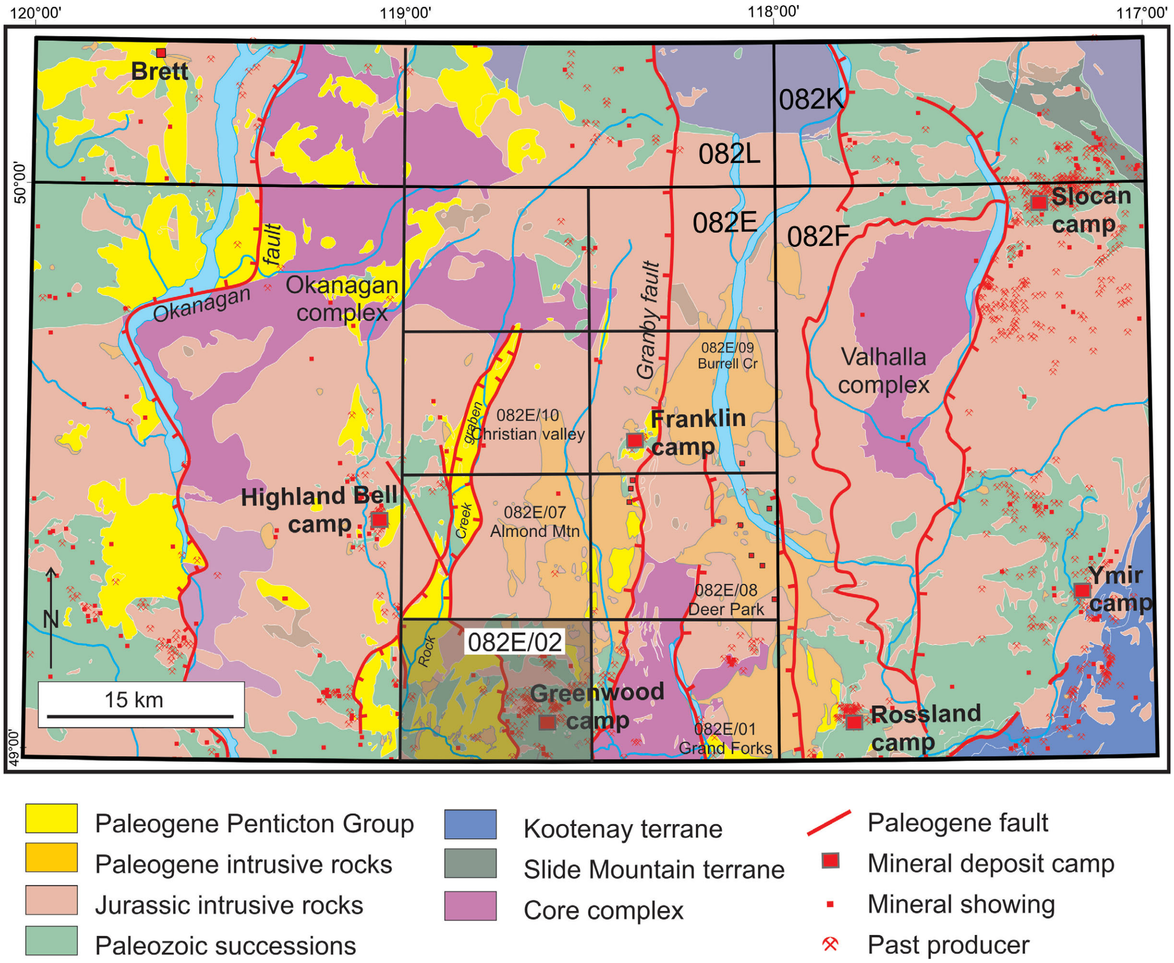


**Figure 1**. Location of the Greenwood map area (NTS 082E/02), southern British Columbia, showing major tectonic elements and locations of recently published 1:50 000 maps (Höy and Jackaman, 2005, 2010, 2013, 2016, 2017): Grand Forks (082E/01), Almond Mountain (082E/07), Deer Park (082E/08), Burrell Creek (082E/09) and Christian Valley (082E/10).

Creek should be referred to as the Anarchist schist, after the original mapping by Daly (1912) and Cairnes (1940). As noted by Massey (op. cit.), they are lithologically similar to the Knob Hill complex, but more argillaceous and complexly deformed. Massey also suggested that similarly deformed rocks farther east in the Greenwood area, referred to as the Knob Hill Group by Fyles (1990), should be included as Anarchist schist. Until more definitive work is done on these Paleozoic rocks, the term Knob Hill complex for these more eastern exposures is preferred (Figure 2).

The Middle to Late Triassic Brooklyn Formation unconformably overlies the Attwood Formation and Knob Hill complex in the central and eastern part of the area. Three main rock types are recognized (Fyles, 1990): chert breccia or 'sharpstone conglomerate'; limestone; and volcanic greenstone, pyroclastic breccia and subvolcanic microbreccia.

The Penticton Group (Church, 1973) is exposed in downdropped blocks throughout the western part of the area, in the southern extension of the Rock Creek graben and northern extension of the Toroda graben in Washington State. A basal unit comprising mainly sandstone and conglomerate, the Kettle River Formation, is overlain by mainly alkalic volcanic rocks of the middle Eocene Marron Formation.

Relatively fresh, massive granodiorite intrusion dominates the northern part of the Greenwood map area and occurs as scattered stocks throughout the remainder of the area. They are included in the Middle Jurassic–Cretaceous Nelson plutonic complex (Little, 1983; Fyles, 1990) due to their lithological similarity with Jurassic plutons to the east, and to a 179.9 ±3.8 Ma U-Pb zircon date on the Greenwood pluton (Massey et al., 2010). Farther north, leucocratic, medium- to coarse-grained granite, the Valhalla intrusion (Little, 1983) or Okanagan batholith (Tempelman-Kluit, 1989) intrudes the granodiorite. It has not been dated within the map area (Figure 2), but several granitic exposures to the north in the Almond Mountain and Christian Valley map areas (NTS 082E/07, 10; Höy, 2016; Höy and DeFields, 2017) have recently been dated by both Ar/Ar and U-Pb zircon geochronology (J. Gabites and R. Friedman, Geochronology Laboratory, The University of British Columbia) as Paleocene. Syenite, part of the middle Eocene Coryell batholith, is exposed in the northeastern part of the Greenwood map area and in small isolated stocks and dikes throughout the area (Figure 2).

Structures in the Greenwood area are dominated by a series of pre-Paleogene, north-dipping thrusts that are commonly marked by lenses of serpentinite (Fyles, 1990; Massey, 2007b). These are overprinted by low- to high-angle normal or extensional faults. In the western part of the area, these late faults bound the structural basins that contain the thick accumulations of Penticton Group sediments and volcanics.

Mineral deposits in the area are described in detail by Peatfield (1978) and Church (1986) and numerous industry

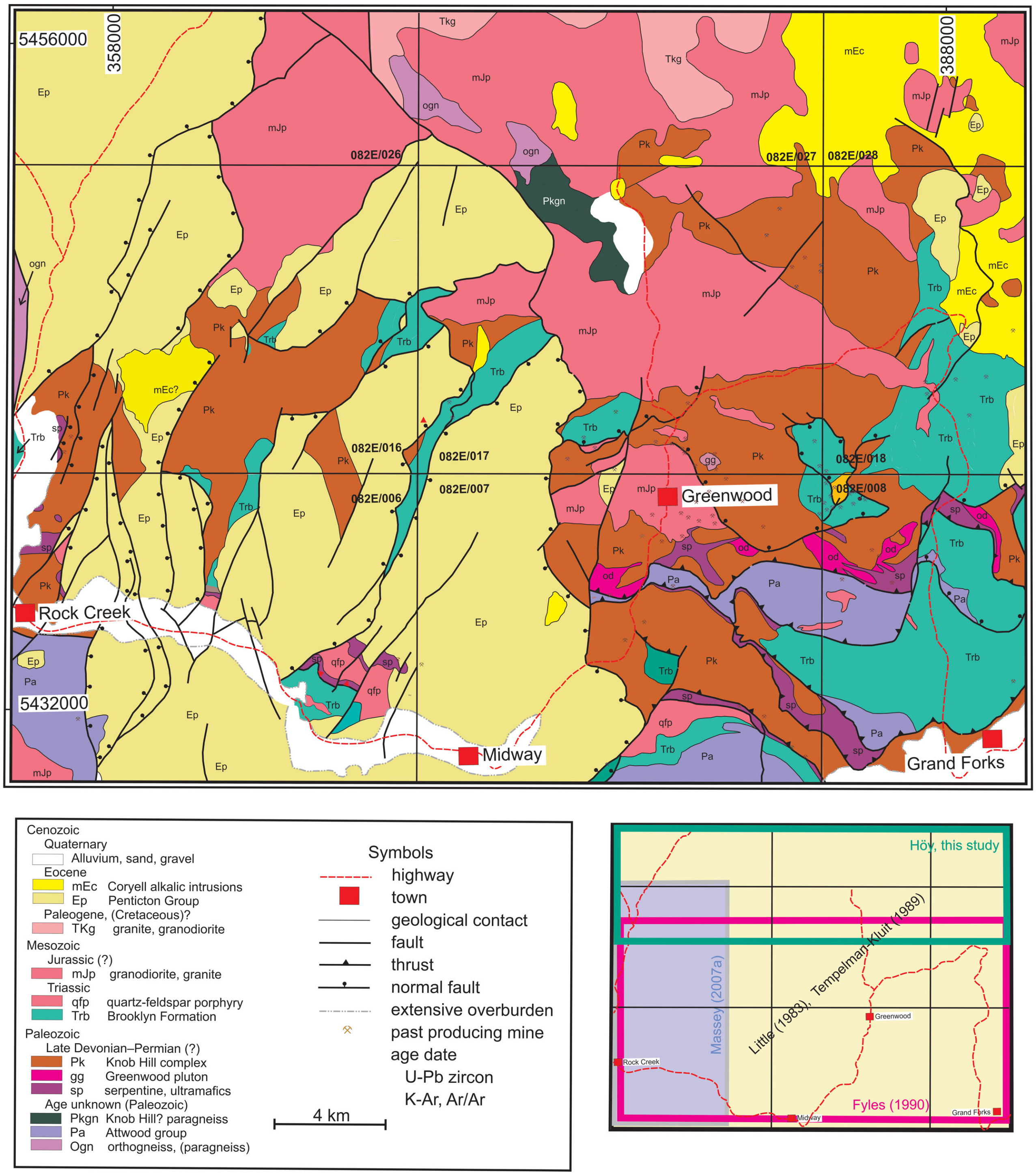


**Figure 2**. Simplified geology of the 1:50 000 scale Greenwood map area (NTS 082E/02), showing locations of past producers. Inset shows the data sources and approximate area of 2017 field mapping (this study).

assessment reports describe recent exploration (e.g., Caron, 2007; Dufresne, 2012). This information is summarized in the BC MINFILE database (BC Geological Survey, 2017), which lists 169 occurrences or deposits throughout the Greenwood map area, including 79 past producers, which are shown in Figure 2.

## Summary

A 1:50 000 scale geological map of the Greenwood map area, including 2017 mapping and a compilation of previous work will be released in 2018. As well, a regional compilation map of the east half of the Penticton map area, including the recently published 1:50 000 Geoscience BC maps to the north and east (Figure 1), will be updated and released in 2018. Isotopic dating of intrusive and volcanic units, currently in progress in the Geochronology Laboratory at The University of British Columbia, will help constrain ages of magmatic events, structures and related mineralization and help define models for known mineralization throughout the Greenwood map area.

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