

# **Tuff of Stampede Pass and Tuff of Green Canyon in the Central Cascade Range, King and Kittitas Counties, Washington**

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Doug Sutherland - Commissioner of Public Lands

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**TUFF OF STAMPEDE PASS AND TUFF OF GREEN CANYON IN THE CENTRAL  
CASCADE RANGE, KING AND KITTITAS COUNTIES, WASHINGTON**

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Table 1. Spreadsheets and Figure 1 and 2 Information. See attached Excel files providing supporting age, stratigraphic, geochemical or mapping information. See Dragovich and Walsh (2008) for further tuff of Stampede Pass geochemical information.

| <b>Figure or<br/>Spreadsheet File<br/>Name</b> | <b>Spreadsheet<br/>Tab Label</b> | <b>Contents or Notes</b>  |
|--|----------------------------------|---|
| Figure 1                                       | NA                               | Simplified geologic map showing the tuff of Stampede Pass and the tuff of Green Canyon  |
| Figure 2                                       | NA                               | Columnar section of the tuff of Stampede Pass and the tuff of Green Canyon  |
| Age and Chem<br>Table.xls                      | Sample locations                 | Sample locations of the tuff of Stampede Pass and the tuff of Green Canyon (Hammond samples)  |
| Age and Chem<br>Table.xls                      | Geochemical<br>Classification    | Tuff of Stampede Pass plot showing geochemical classification plot  |
| Age and Chem<br>Table.xls                      | Representative XRF<br>and Modes  | Representative XRF geochemical analyses and modes for the tuff of Stampede Pass and the tuff of Green Canyon (Hammond samples)                    |
| Age and Chem<br>Table.xls                      | Incremental Heating<br>Ages      | Ar-Ar incremental heating ages for the tuff of Stampede Pass and the tuff of Green Canyon (Hammond samples)                                       |
| Age and Chem<br>Table.xls                      | Dragovich U-Pb                   | U-Pb zircon data for the tuff of Stampede Pass in the North Bend quadrangle. See Dragovich and others (2009) for further data and interpretations |
| Age and Chem<br>Table.xls                      | Stratigraphic<br>Correlations    | Stratigraphic correlations in the map area (Fig. 1). Provides correlations between Tabor and others (2000) and the terminology of Hammond (1963)  |
| Chem Data.xls                                  | Geochem Data                     | Tuff of Stampede Pass geochemical data (Hammond)  |
| Chem Data.xls                                  | Zr vs TiO(2)                     | Plot of Zr vs TiO(2) for the tuff of Stampede Pass  |
| Chem Data.xls                                  | Geochem Data 2                   | Tuff of Stampede Pass geochemical data with further sample and lithologic information (See Geochem Data tab.)                                     |

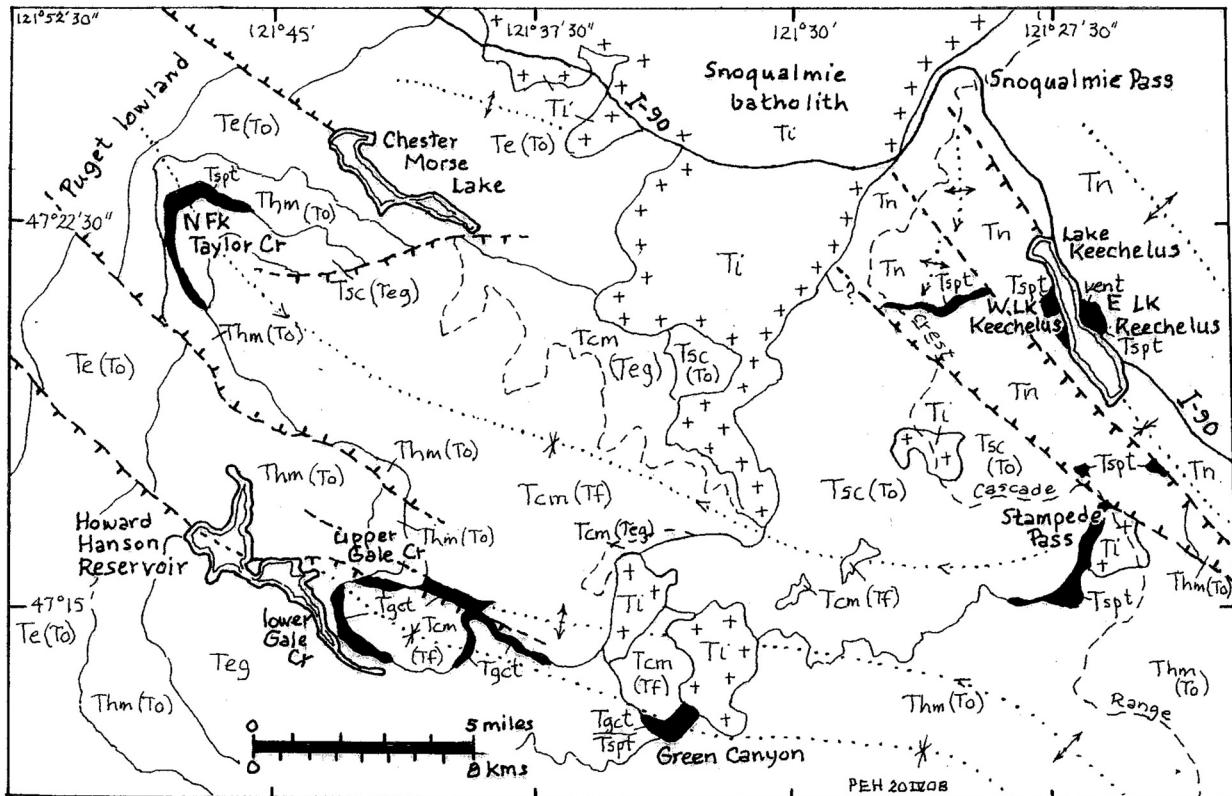


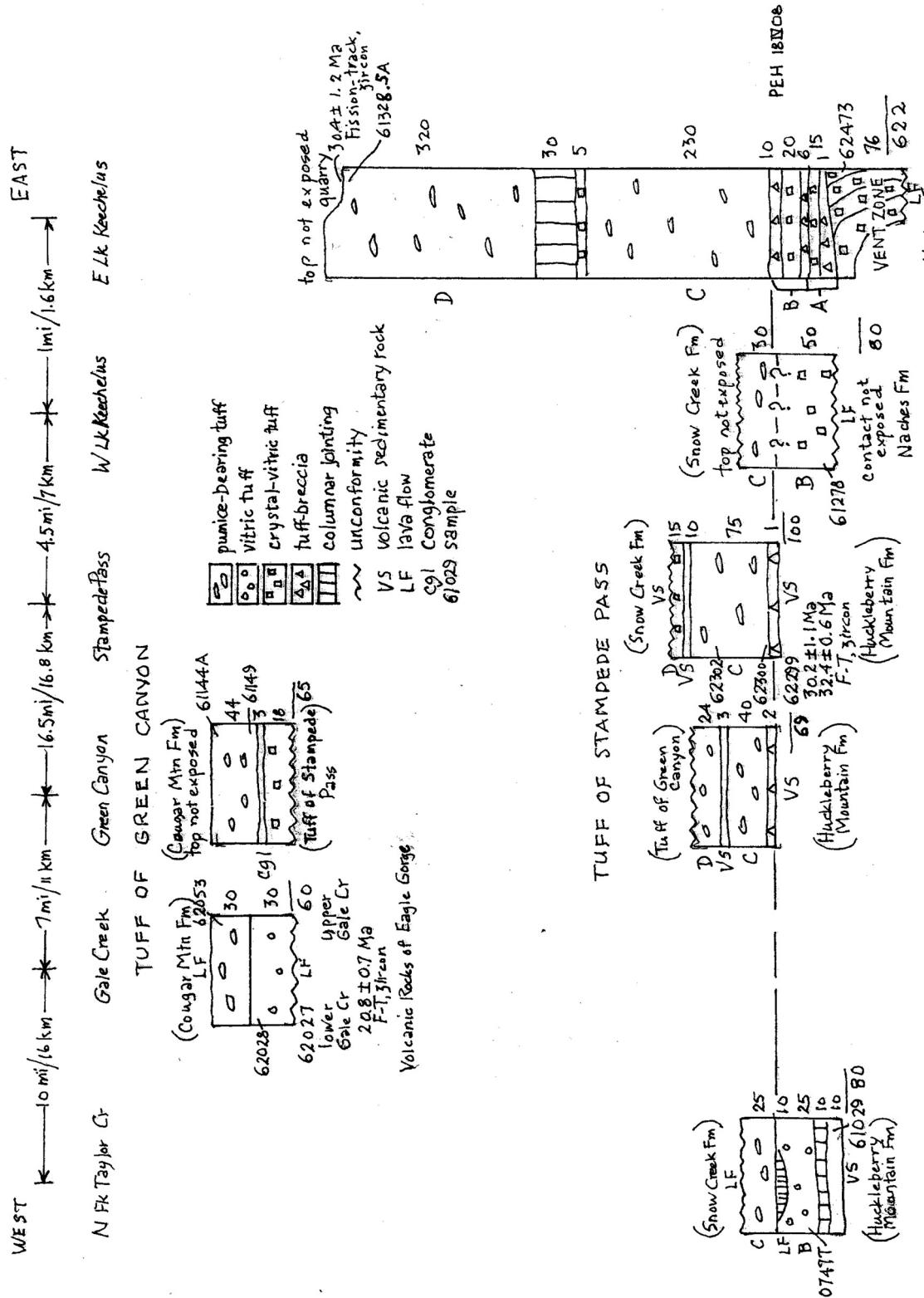
Figure 1. Distribution of tuffs of Stampede Pass (Tspt) and Green Canyon (Tgct) in central Cascade Range, Washington. Shows locations of sections; refer to Figure 2. See text for identification of map symbols for geologic units; symbols in parentheses are calls of Tabor and others (2000).

**Definition.** The tuff of Stampede Pass and tuff of Green Canyon are two very similar tuff units, forming stratigraphic markers, in the central Cascade Range, Washington (Fig. 1). They are of similar composition, have similar textures, but differ in age by 3 m. yrs. and are in unconformable stratigraphic contact along the Green River. Both units consist chiefly of rhyodacitic-rhyolitic clinopyroxene-quartz-plagioclase vitric tuff (Age and Chem Table.xls). The older unit, the tuff of Stampede Pass, is age-dated at 29.9 to 28.2 Ma ( $^{40}\text{Ar}/^{39}\text{Ar}$ , plagioclase), 31.1 to 29.3 (U-Pb), and 32.5 to 30.2 Ma (fission-track, zircon; Fig. 2; See Table 1 for spreadsheet information). Dragovich and others (2009) report a U-Pb zircon age of 29.0 Ma in the N. Fork Taylor Creek area. They also suggest that a zircon fission-track age of  $24.7 \pm 1.7$  Ma reported by Tabor and others (2000) from the tuff near Taylor Creek (age site 2 of Dragovich and others) in the southeast part of the map area is probably too young and may be reset by nearby Miocene dikes. This reset age site is near an older Ar-Ar plateau age of  $27.87 \pm 0.06$  Ma age site from the tuff collected by Hammond providing evidence that the 24 Ma age is too young. The tuff of Green Canyon is 24.9 to 23.4 Ma ( $^{40}\text{Ar}/^{39}\text{Ar}$ , plagioclase) and 20.8 Ma (fission-track, zircon).

The tuff of Stampede Pass erupted from an asymmetrical funnel-shaped vent, about 1 km in length and 75 m in width, exposed in the Interstate 90 road cut along the eastern shore of Lake Keechelus (Hammond, 1963). From there it extended discontinuously west about 50 km to the foothills overlooking Puget lowland (Figs. 1 and 2). Its thickness ranges from a maximum of 700 m along the eastern shore of Lake Keechelus to 80 m in the North Fork Taylor Creek area

between the Cedar and Green rivers. It was considered to be the first tuff unit recognized extending from the east flank of the Cascade arc across the west flank. Subsequent mapping by Tabor and others (2000) found the tuff unit to differ in age, based on fission-track, zircon, dates (Fig. 2), leading them to separate the tuff into several units. That part in the Lake Keechelus area they designated the tuff member of Lake Keechelus (Tolk) of the Ohanapecosh Formation. The part in the Stampede Pass area was not separately identified and included in the Ohanapecosh Formation (see correlation of stratigraphic units in section on stratigraphy). Along the Green River the tuff was designated rhyodacite tuff (Tfrt), forming the base of the Fifes Peak Formation (Tf), separating it unconformably from the underlying volcanic rocks of Eagle Gorge (Teg). And to the northwest in the North Fork Taylor Creek area the tuff was mapped at the top of the Ohanapecosh Formation at the unconformable contact with the overlying volcanic rocks of Eagle Gorge (Dragovich and others, 2009). We tentatively interpret these separate tuff designations to be part of one unit because of their similar mineralogy, chemical composition, texture, stratigraphic position, and closely similar ages. That part along the Green River; however, being very similar to the tuff of Stampede Pass, but separated unconformably and differing in age by 3 m. yrs., we designate as a different tuff unit, the tuff of Green Canyon (Tgct). It crops out only along the Green River and has a maximum exposed thickness of 65 m. Its source is unknown; being 3 m. yrs. younger than the tuff of Stampede Pass, it is doubtful that it erupted from the same vent at Lake Keechelus. Furthermore, no evidence of a younger intrusive tuff was found in this vent.

**Lithology.** Both tuff units are generally pale brown to light gray in color, locally pale green. Pumice is brownish to yellowish. Blocky to slabby jointing is common except for rare columnar jointing. Eutaxitic layering with flattened pumice and aligned crystals occur in weakly welded zones. Volcanic sedimentary interbeds, up to 1 m thick, are similarly colored, coarse- to fine-grained, laminated- to cross-bedded, and well indurated. Conglomerate, up to 5 m thick, with generally well-rounded cobble and smaller size clasts, and tuff-breccia are darker in color, grayish, massive, matrix supported, and well indurated. Lithic clasts are generally porphyritic andesite. The one interbedded lava flow in the tuff of Stampede Pass (Fig. 2) is a dark gray, porphyritic andesite with blocky to platy jointing and bottom and top breccia; it is a valley-filling flow 5-10 m thick but thickens to 200 m east of the section. In hand specimens of both tuff units, rounded quartz, prisms of plagioclase, dark grains, lithic particles, and pumice are readily identifiable. Under the microscope both tuff units contain scattered, subhedral to anhedral prisms, ~0.25-2.25 mm, of plagioclase, An<sub>57-17</sub>, some partly altered to epidote and calcite, together with surrounded and embayed quartz crystals, anhedral prisms of clinopyroxene (augite), generally completely altered to brownish clay, Fe oxide, and chlorite, anhedral opaque oxides, devitrified attenuated pumice, rounded lithic clasts, generally of phric andesite, partly altered to chlorite, carbonate, epidote, and Fe oxides, in a devitrified vitroclastic matrix. Fractured and displacement of plagioclase and quartz occurs in the eastern extent of the tuff of Stampede Pass, indicative of compressional deformation in the Lake Keechelus-Stampede Pass area subsequent to its deposition. The range of mode in both units is shown in Age and Chem Table.xls spreadsheet (Table 1). There is a subtle decrease in size and percentage of crystals westward in the tuff of Stampede Pass.



Columnar sections of tuff of Stampede Pass and tuff of Green Canyon, showing eruptive units, A-D, principle lithologies, thicknesses in meters (not to scale), and sample sites (see Table 4). Horizontal line through sections shows possible correlative units. Fission-track dates from Tabor et al., 2000.

**Stratigraphy.** Representative columnar sections, from east to west, show the stratigraphy within the tuffs of Stampede Pass and Green Canyon (Fig. 2). The tuff of Stampede Pass contains possibly as many as four eruptive units, as pyroclastic flows, identified as A through D; not all are preserved in one section. A pumice-rich unit C, possibly correlative, passes through the

approximate middle of the sections. The tuff of Green Canyon consists of two eruptive units. In the Green Canyon section it rests unconformably upon the tuff of Stampede Pass. Figure 2 also shows the geologic units in contact with the tuff deposits (see Fig. 1).

Most eruptive units in both tuff deposits consist of crystal- and pumice crystal-vitric tuff. Lithic and pumice tuff-breccia occur only in the eastern part of the tuff of Stampede Pass, and generally grade upward into finer crystal- and pumice crystal-vitric tuff. Contacts between eruptive units in both tuff deposits, although not exposed everywhere, are located at the top of volcanic sedimentary interbeds, conglomerate, lava flows, at the base of lithic and/or pumice tuff-breccia, and at the base of crystal-vitric tuff with abundant carbonized wood.

Tracing the tuff of Stampede Pass in the central Cascade Range helps in simplifying the regional stratigraphy. From the list above and shown in Figure 1, we interpret that the Huckleberry formation of Hammond (1963) is equivalent in the map area to the Ohanapecosh Formation. With further mapping and supportive geologic information future workers might consider excluding the tuff of Stampede Pass from the Ohanapecosh Formation. It probably overlies unconformably and is a marker bed at the top of the Ohanapecosh Formation, although Dragovich and others (2009) were unable to confirm this unconformity because of limited exposure in the North Bend 7.5-minute quadrangle. (The tuff of Stampede Pass is also a marker bed unconformably underlying the Snow Creek formation of Hammond (1963).) Moving up stratigraphically, the volcanic rocks of Eagle Gorge (Eagle Gorge andesite of Hammond, 1963) overlie unconformably the Ohanapecosh-Huckleberry Mountain formation, and are overlain unconformably by the Fifes Peak Formation. In the North Bend 7.5-minute quadrangle Dragovich and others (2009) included the Enumclaw formation and parts of the Snow Creek and Huckleberry formations in the Ohanapecosh Formation of Tabor and others (2000). The tuff of Green Canyon, overlying unconformably the volcanic rocks of Eagle Gorge, is a marker bed at the base of the Fifes Peak Formation. The Fifes Peak Formation in the map area is composed of the Snow Creek and Cougar Mountain formations of Hammond (1963) as well as the tuff of Green Canyon.

Contact relations. At the surface the vent of the tuff of Stampede Pass cuts andesitic lava flows of the upper part of the Naches Formation (Figs. 1 & 2). Southeast of the vent and on the west side of Lake Keechelus the tuff unit unconformably overlies Naches lava flows. In this area the top of the unit is eroded and its upper contact is not exposed. In the upper Yakima River valley, in which Lake Keechelus is situated, several northwest-striking faults (Fig. 2) break up the continuity of the tuff unit. West of Lake Keechelus and the Cascade crest the tuff unit is intruded by the Snoqualmie batholith and not well exposed in steep, forested terrain. At Stampede Pass the unit unconformably overlies volcanic sedimentary rocks of Ohanapecosh-Huckleberry Mountain formation. To the southwest of the pass the tuff is in uncomfortable contact with the Ohanapecosh-Huckleberry formation and with the overlying Snow Creek formation, part of the Fifes Peak Formation, but assigned to the Ohanapecosh Formation (Tabor and others, 2000). In the Green River valley the tuff of Stampede Pass forms the lower part of the tuff section at Green Canyon, there unconformably overlying the volcanic rocks of Eagle Gorge. The upper part of the tuff section at Green Canyon forms the tuff of Green Canyon. North of the valley the tuff of Green Canyon is overlain conformably by the Cougar Mountain formation of Hammond (1963), which is assigned to the Fifes Peak Formation by Tabor and others (2000). In its northwestern

extent (Fig.1) the tuff of Stampede Pass unconformably overlies Huckleberry Mountain formation, here assigned to the volcanic rocks of Eagle Gorge (Tabor and others, 2000) and unconformably underlies Snow Creek formation (of Fifes Peak Formation).

Age and Further Work. Ages of the tuffs of Stampede Pass and Green Canyon are listed in Age and Chem Table.xls and shown in Figure 2. With further geochemistry, mapping and most importantly (quality radiometric age data) future workers should consider our hypothesis that the tuff of Stampede Pass is a regional marker bed in the southern Cascades. Also, a detailed evaluation should be made concerning the effects heating, alteration, and the “old zircon problem” have radiometric age dating of volcanics in the area.

References cited.

Dragovich, J. D.; Walsh, Timothy J.; Anderson, M. L.; Hartog, Renate; DuFrane, S. A.; Vervoort, Jeff; Williams, S. A.; Cakir, Recep; Stanton, K. D.; Wolff, F. E.; Norman, D. K.; Czajkowski, J. L., 2009, Geologic map of the North Bend 7.5-minute quadrangle, King County, Washington, with a discussion of the major faults, folds, and basins in the map area: Washington Division of Geology and Earth Resources Geologic Map GM-73, 1 sheet, scale 1:24,000, with 39 p. text. [[http://www.dnr.wa.gov/Publications/ger\\_gm73\\_geol\\_map\\_northbend\\_24k.zip](http://www.dnr.wa.gov/Publications/ger_gm73_geol_map_northbend_24k.zip)]

Dragovich, J. D.; Walsh, T. J., 2008, Geochemical sample analyses of Tertiary and pre-Tertiary volcanic rocks in and around the North Bend 7.5-minute quadrangle, King County, Washington: Washington Division of Geology and Earth Resources Open File Report 2008-4, 1 Microsoft Excel file with 6 p. text. [[http://www.dnr.wa.gov/Publications/ger\\_ofr2008-4\\_northbend\\_geochem.zip](http://www.dnr.wa.gov/Publications/ger_ofr2008-4_northbend_geochem.zip)]

Hammond, P. E., 1963, Structure and stratigraphy of the Keechelus volcanic group and associated Tertiary rocks in the west-central Cascade Range, Washington: University of Washington Doctor of Philosophy thesis, 254 p., 2 plates.

Tabor, R. W.; Frizzell, V. A., Jr.; Booth, D. B.; Waitt, R. B., 2000, Geologic map of the Snoqualmie Pass 30 x 60 minute quadrangle, Washington: U.S. Geological Survey Geologic Investigations Series Map I-2538, 1 sheet, scale 1:100,000, with 57 p. text. [<http://geopubs.wr.usgs.gov/i-map/i2538/>]