U.S. DEPARTMENT OF THE INTERIOR
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Sheet 2 of 2

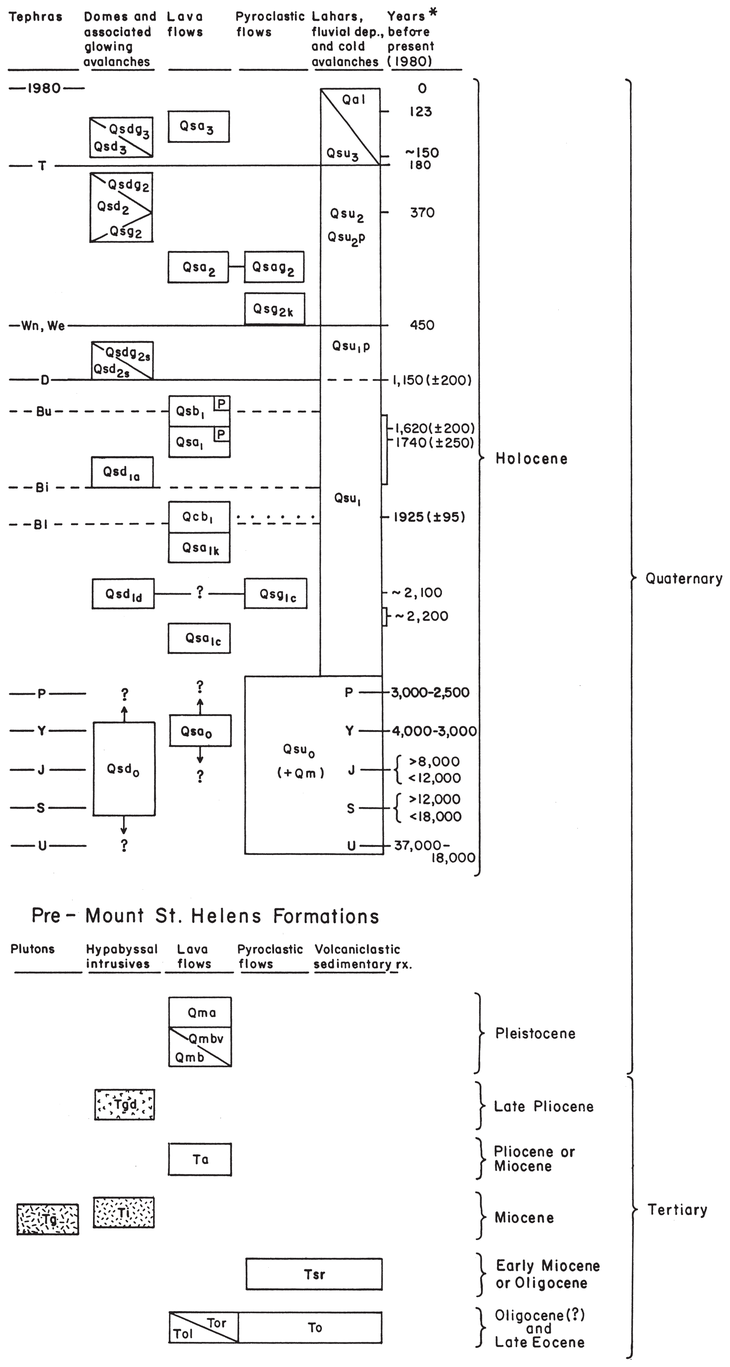
MOUNT ST. HELENS VOLCANIC CENTER

Rocks and unconsolidated deposits of Mount St. Helens volcanic center are divided for mapping purposes into four chronologic groups, which also represent distinctive stages in its petrologic evolution and eruptive history. These groups are: (1) the Qs_0 units, formed during the interval from about 40,000 years B.P. (U tephra and associated pyroclastic flows) to about 2,500 years B.P. (top of tephra set P); (2) the Qs_1 units, formed from about 500 B.C. (2,500 years B.P.) to about 400 A.D. (top of tephra set B); (3) Qs_2 units, formed from about 800-900 A.D. (earliest W tephra) to about 1,650 A.D. (latest pre-T units); and (4) Qs_3 units, formed during the historic eruption cycle which began about 1,800 A.D. and lasted to 1857.

The stages represented by these four groups are: stage 1 (Qs_0 map units), the prolonged evolution of an older St. Helens volcanic center, characterized by explosive domes of hornblende-rich dacite, abundant pumiceous tephras, and voluminous valley-filling assemblages of pyroclastic flows and lahars; stage 2 (Qs_1 map units), the early development of modern Mount St. Helens volcano, marked by a change to cone-building lava flows of pyroxene andesite and streams of olivine basalt, with hypersthene dacite domes and pyroclastic flows but restricted tephras; stage 3 (Qs_2 and Qs_3 map units), episodic eruptions of tephra and dacite domes, usually with flank eruptions of pyroxene andesite. The last two eruptive periods show a cyclic pattern: (1) voluminous pumice eruptions 460 years ago (tephra set W) were followed by growth of the dacitic summit dome, then flank eruptions of pyroxene andesite lava and andesitic glowing avalanches (pyroclastic flows); (2) the pumice eruption 180 years ago (T tephra) was followed, during the period 1831-57, by growth of the dacitic Goat Rocks dome and small andesitic lava flows. Lahars have accompanied all eruptive stages at Mount St. Helens.

CORRELATION OF MAP UNITS

Mount St. Helens Volcanic Center



Pre - Mount St. Helens Formations

* Age data shown here are taken from the historical record (Holmes, 1955), from tree ring counts (Crandell, 1971; Hopson, unpublished data), from published C^{14} ages (Greeley and Hyde, 1972; Crandell and Mullineaux, 1973; Mullineaux, Hyde, and Rubin, 1975), and from a compilation of eruption ages based on all available age data (Crandell, Mullineaux, and Rubin, 1975).

DESCRIPTION OF MAP UNITS

MOUNT ST. HELENS VOLCANO

Modern glaciers on Mount St. Helens. Some have retreated slightly from terminal positions shown on the map.

Qsu3: Qsu_3: unconsolidated deposits younger than tephra set T; chiefly laharic and fluvial deposits occupying modern stream channels, but including avalanche deposits and scree on the flanks of the cone.

Qsa3: Qsa_3: hypersthene-augite andesite flows on northwest flank of cone younger than tephra T, and olivine-pyroxene andesite flow on southwest flank of cone of similar very young age.

Qsd3: Qsd_3: augite-hornblende-hypersthene dacite of Goat Rocks dome; younger than T tephra.

Qsdg3: $Qsdg_3$: dacitic hot block avalanche and laharic deposits from Goat Rocks dome; younger than T tephra.

—T— T tephra: dacitic pumice and ash. Fe-Mg phenocrysts are chiefly hypersthene and hornblende, with subordinate augite.

Qsu2: Qsu_2: unconsolidated deposits younger than set W tephra (layers n, e) but older than Set T tephra; chiefly laharic and fluvial deposits on the lower flanks of the cone and in stream valleys, and avalanche deposits higher on the flanks of the cone; clast assemblages characteristically contain summit-dome dacite (Qsd_2).

Qsu2p: Qsu_2p: unconsolidated deposits heavily mantled by pumice on the northeast side of the cone.

Qsd2: Qsd_2: augite-hornblende-hypersthene dacite of dome forming the summit of Mount St. Helens ("summit dome"); older than set T tephra but younger than augite-hypersthene andesite lava flows (Qsa_2).

Qsdg2: $Qsdg_2$: dacitic glowing avalanches and cold avalanches from the summit dome, and associated laharic deposits; older than set T tephra but younger than Qsa_2 andesite.

Qsg2: Qsg_2: glowing-avalanche deposit of olive-gray dacite on western flank of the cone; lies immediately beneath $Qsdg_2$.

Qsag2: $Qsag_2$: augite-hypersthene andesite glowing-avalanche deposits approximately coeval with Qsa_2 andesite lava flows; older than summit dome deposits Qsd_2, $Qsdg_2$, and Qsg_2 but younger than set W tephra and glowing-avalanche deposits of Kalama River (Qsg_{2k}).

Qsa2: Qsa_2: augite-hypersthene andesite lava flows older than summit dome deposits Qsd_2, $Qsdg_2$, and Qsg_2 but younger than set W tephra and glowing-avalanche deposits of Kalama River (Qsg_{2k}).

Qsg2k: Qsg_{2k}: hypersthene-hornblende dacite glowing-avalanche deposits of Kalama River; older than $Qsag_2$ pyroxene andesite glowing-avalanche deposits of upper Kalama River drainage but younger than W tephra.

—Wn,We— W tephra: dacitic pumice and ash. Mafic phenocryst assemblage is hypersthene and hornblende. Layer We within thi tephra set extends mainly to the east of the volcano, while stratigraphically lower Wn layer extends mainly northeast and north (Mullineaux et.al, 1975). Layer Wn is dated at about 450 years B.P. by tree ring counts (Crandell, 1971).

Qsdg2s: $Qsdg_{2s}$: dacitic glowing-avalanche deposit from Sugarbowl dome. Older than tephra set W, but younger than Qsb_1 basalt.

Qsd2s: Qsd_{2s}: hornblende-hypersthene dacite of Sugarbowl dome; older than tephra set W, but younger than Qsb_1 basalt.

—D— D tephra layer: dacitic lithic ash and pumice lapilli; hypersthene-hornblende mafic phenocryst assemblage. C^{14} age about 1,150 ± 200 years B.P. (Mullineaux et. al., 1975).

Qsu1: Qsu_1: unconsolidated deposits older than set W tephra but younger than Qsu_0 pyroclastic-laharic assemblages; chiefly laharic deposits on the lower flanks of the cone and in adjacent stream valleys, and mainly avalanche and glacial deposits higher on the cone; clast assemblages lack summit-dome dacite (Qsd_2) but contain black andesite and basalt (Qsa_1 and Qsb_1).

Qsu1p: Qsu_1p: unconsolidated deposits heavily mantled by pumice on the northeast side of the cone.

Qsb1: Qsb_1: olivine basalt and subordinate olivine andesitic-basalt lava flows, typically in sequences of thin (3-8 foot) flows on the flanks of the cone and in thicker aa flows near the base of the cone; older than set W tephra but younger than the lower units of set B tephra.

Qsb1p: Qsb_1p: olivine basalt heavily mantled by pumice on the northeast side of the cone.

Qsa1: Qsa_1: hypersthene-augite andesite lava flows older than set W tephra and Qsb_1 basalt, but younger than Qsu_0 pyroclastic-laharic deposits; a late phase of this andesite lies directly beneath Qsb_1 basalt and appears to be only slightly older; an earlier phase of the andesite occurs beneath lower units of the set B tephra.

Qsa1p: Qsa_1p: hypersthene-augite andesite heavily mantled by pumice on the northeast side of the cone.

Qsd1a: Qsd_{1a}: hypersthene dacite of Abraham Flat dome; older than set W tephra but younger that set Y tephra; probably formed within the span of tephra set B.

—B— B tephras: includes an upper unit of olivine-bearing basaltic scoria and ash, a local middle unit of hypersthene-rich dacitic ash (restricted to east side of the cone), and lower units that include more olivine-bearing basaltic scoria and ash. (Data from Crandell and Mullineaux, 1973; Mullineaux, Hyde, and Rubin, 1975; Mullineaux unpublished; and Hopson unpublished).

Qcb1: Qcb_1: Cave basalt; chemically primitive, diktytaxitic olivine basalt erupted from near the southwestern foot of Mount St. Helens; forms large pahoehoe flows with lava tubes; older than the Qsb_1 basalt but younger than the Qsu_0 pyroclastic-laharic deposits; charcoal C^{14} of 1860±250 and 1925±95 years B.P. (Greeley and Hyde, 1972).

Qsa1k: Qsa_{1k}: aphyric pyroxene andesite lava flow of Kalama Springs area; older than Cave basalt (Qcb_1) but younger than Qsu_0 pyroclastic-laharic deposits; occurs immediately beneath the Cave basalt and appears to be only slightly older.

Qsg1c: Qsg_{1c}: sub-pumiceous hypersthene dacite glowing-avalanche deposit of Studebaker Creek, Castle Creek, and South Toutle River drainages; older than Qsa_1 andesite of South Toutle River gorge and Qsb_1 basalt, but younger than Qsa_{1c} andesite of Castle Creek and Qsu_0 pyroclastic-laharic deposits; interbedded with set B tephra.

Qsd1d: Qsd_{1d}: Hypersthene dacite of Dogs Head dome; older than set W tephra and Qsb_1 basalt, but younger than set Y tephra; probably formed within the span of tephra set B.

Qsa1c: Qsa_{1c}: Augite-hypersthene andesite lava flow of lower Castle Creek; older than most B tephras but younger than Qsu_0 pyroclastic-laharic deposits.

Qsu0: Qsu_0: Unconsolidated deposits from the older volcanic center, chiefly pyroclastic-flow and laharic deposits characterized by clast assemblages of gray, pink, and red hornblende-hypersthene dacite and andesite; also includes minor glacial deposits. Older than Qs_1 units and set B tephras, and interbedded with tephra of sets P, Y, J, S, and an older unnamed tephra set.

—P— —Y— —J— —S— —U—

Qsa0: Qsa_0: hornblende(opacitic)-augite-hypersthene andesite, occurring as thick lava lobes and flows in the Swift Creek drainage and near the head of Pine Creek; older than Qsb_1 basalt, and coeval in part with Qsu_0 pyroclastic-laharic deposits.

Qsd0: Qsd_0: hornblende-hypersthene dacite and andesite, forming remnants of domes of the older volcanic center. Older than the Qs_1 units, and coeval in part with the Qsu_0 pyroclastic-laharic assemblages. Includes the Loowit Creek dome, West dome, Kalama River dome, Butte Camp dome, and Southwest dome.

OTHER QUATERNARY DEPOSITS

Qal: Qal: alluvium, chiefly in stream valleys. There is no sharp distinction from the youngest Mount St. Helens unconsolidated deposits (Qsu_3) adjacent to the volcano.

Qm: Qm: glacial moraines and other undifferentiated glacial deposits. Some glacial deposits on Mount St. Helens may also be labeled Qsu.

FORMATIONS OLDER THAN MOUNT ST. HELENS

MARBLE MOUNTAIN VOLCANO

Qmb: Qmb: gray microphyric olivine basalt forms the bulk of Marble Mountain shield volcano; thick cover of older Mount St. Helens tephras overlies most of this area.

Qmbv: Qmbv: vent areas, marked by accumulations of cinders and bombs.

Qma: Qma: aphyric and microphyric hornblende andesite, erupted from vent on south flank of Marble Mountain.

ANDESITES OF SMITH CREEK BUTTE

Ta: Ta: pyroxene andesite and olivine-pyroxene andesite remnants in upper Smith Creek canyon. These lavas are more abundant on Smith Creek Butte and elsewhere just east and southeast of the map area. Possibly equivalent to Fifes Peak Formation.

STEVENS RIDGE FORMATION

Tsr: Tsr: partly welded rhyodacitic ash-flow tuff and associated tuffaceous sedimentary rocks. More abundant just east and southeast of the map area.

OHANAPECOSH FORMATION

To: To: andesitic and dacitic tuff-breccia and volcaniclastic sedimentary rocks. Widespread zeolite facies alteration.

Tol: Tol: chiefly pyroxene andesite lava flows and associated breccias, marking local volcanic centers. Interfingers laterally with the volcaniclastic member (To).

Tor: Tor: rhyolite.

INTRUSIVE ROCKS

Tgd: Tgd: biotite-hornblende dacite porphyry of Goat Mountain plug. The provisional age is Pliocene, based on the following discordant $^{40}K/^{40}Ar$ mineral ages: hornblende 3.1±.3 m.y., biotite 1.0±.1 and 0.74±.1 m.y. (Rowland Tabor, analyst).

Ti: Ti: hypabyssal intrusive rocks, chiefly pyroxene microdiorite and granodiorite porphyry. Forms an intrusive complex in the Ohanapecosh Formation south of Merrill Lake. Also, forms dike and sill complexes (not distinquished separately on the map) in the Ohanapecosh Formation on the north side of Spirit Lake (adjacent to the Spirit Lake pluton, just off the map), and on the south and north sides of Swift Reservoir. Age of the hypabyssal intrusives in the Spirit Lake area is probably Early Miocene, based on a hornblende $^{40}K/^{40}Ar$ age of 21 m.y. for granodiorite of the Spirit Lake pluton (Rowland Tabor, analyst).

Tg: Tg: epizonal granodiorite, in small intrusive masses at Cinnamon Peak and Mount Mitchell (just south of map area).

References Cited

Crandell, D.R., 1971, Postglacial lahars from Mount Rainier volcano, Washington: U. S. Geological Survey Prof. Paper 677, 75p.

Crandell, D.R., and Mullineaux, D.R., 1973, Pine Creek volcanic assemblage at Mount St. Helens, Washington: U.S. Geol. Survey Bull. 1383-A, 23 p.

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Greeley, R., and Hyde, J.H., 1972, Lava tubes of the Cave Basalt, Mount St. Helens, Washington: Geol. Soc. America Bull., v. 83, p. 2397-2418.

Holmes, K.L., 1955, Mount St. Helens recent eruptions: Oregon Historical Quarterly, v. 61, no. 3, p. 197-210.

Mullineaux, D.R., Hyde, J.H., and Rubin, M., 1975, Widespread late glacial and post-glacial tephra deposits from Mount St. Helens volcano, Washington: U.S. Geol. Survey Jour. Research, v. 3, p. 329-335.

GEOLOGIC SYMBOLS

Contact
Dashed where gradational or approximately located
Dotted where concealed

Syncline

30 Inclined bedding

Joints
Parallels flow contacts in Tsr and Tol volcanic rocks

Geologic Map of Mount St. Helens, Washington Prior to the 1980 Eruption

by

Clifford A. Hopson

2008

Note
Michael A. Clynne

It is rare that a geologic map exists for a volcano prior to such a catastrophic modification as that produced by the eruption of Mount St. Helens in 1980. As such, this map provides an important historical record of the volcano prior to that eruption. The map has not been reviewed or checked for conformity to USGS editorial standards or stratigraphic nomenclature, and it has not been digitized. This version of the map is unchanged from that submitted to the USGS for publication shortly after the 1980 eruption of Mount St. Helens and includes unresolved inconsistencies with the subsequently published work of Crandell (1987) and Mullineaux (1996). Nevertheless, it is the most accurate available depiction of the pre-1980 edifice and is published here for comparison with more recent geologic mapping and historical perspectives.

Crandell, D. R., 1987, Deposits of the pre-1980 pyroclastic flows and lahars from Mount St. Helens Volcano, Washington: U.S. Geological Survey Professional Paper 1444, 91 p.

Mullineaux, D. R., 1996, Pre-1980 tephra-fall deposits erupted from Mount St. Helens, Washington: U.S. Geological Survey Professional Paper 1563, 99 p.

Digital restoration by David W. Ramsey