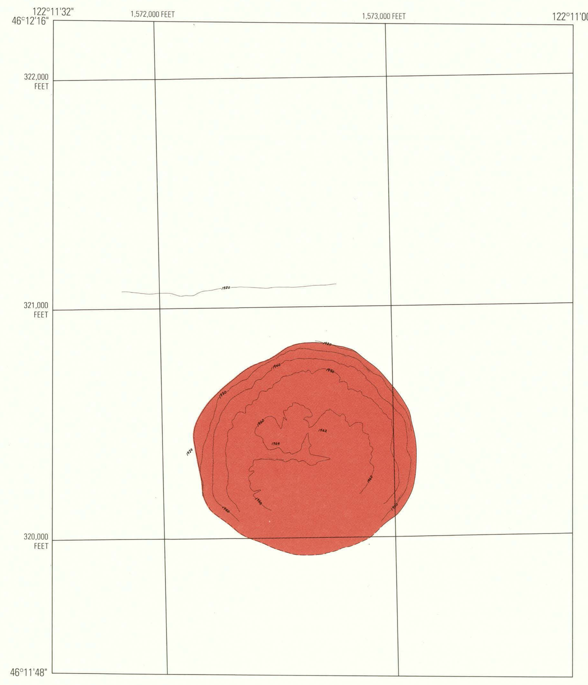
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

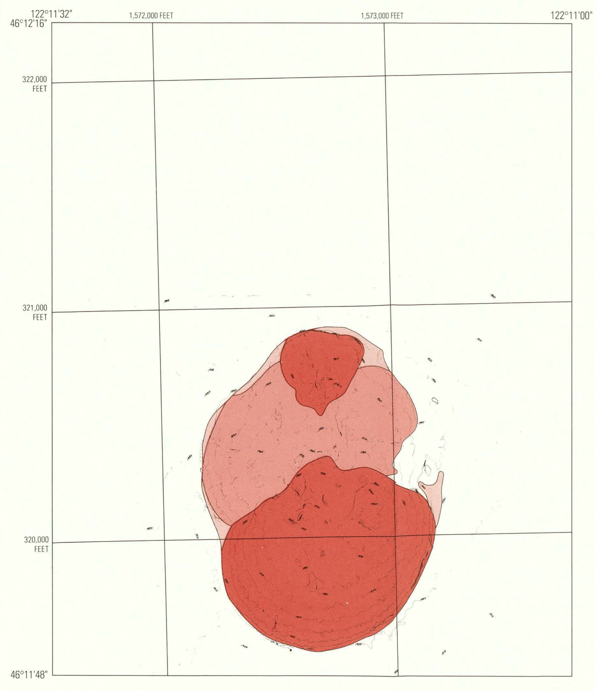
MISCELLANEOUS INVESTIGATIONS SERIES
MAP I-2359



Base compiled by U.S. Geological Survey, 1982-83, from Washington Department of Transportation aerial photographs 195-196 of flightline 35
Lambert Conformal Conic projection

Geology mapped in 1984

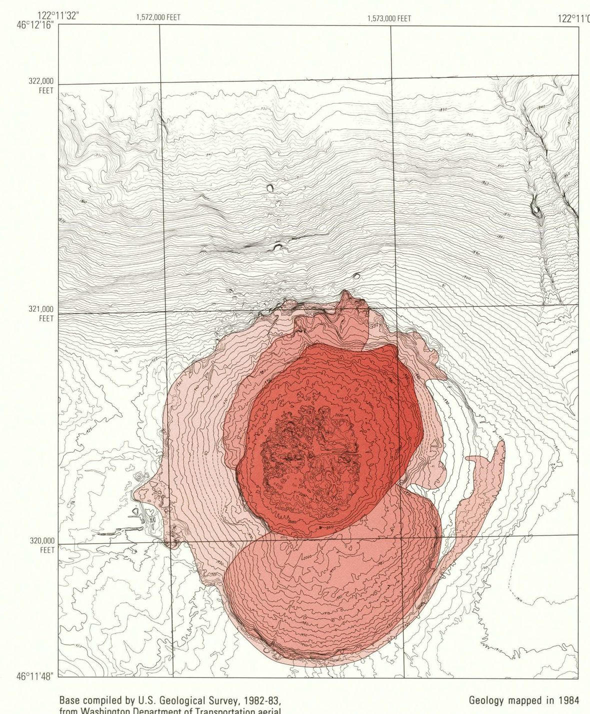
Principal photography October 23, 1980
Eruption beginning October 18, 1980 (3)



Base compiled by U.S. Geological Survey, 1982-83, from Washington Department of Transportation aerial photographs 268-270 of flightline 48
Lambert Conformal Conic projection

Geology mapped in 1984

Principal photography January 15, 1981
Eruption beginning December 27, 1980 (7)



Base compiled by U.S. Geological Survey, 1982-83, from Washington Department of Transportation aerial photographs 304-306 of flightline 54, supplemented by frames 317-318 of flightline 56 (March 27)
Lambert Conformal Conic projection

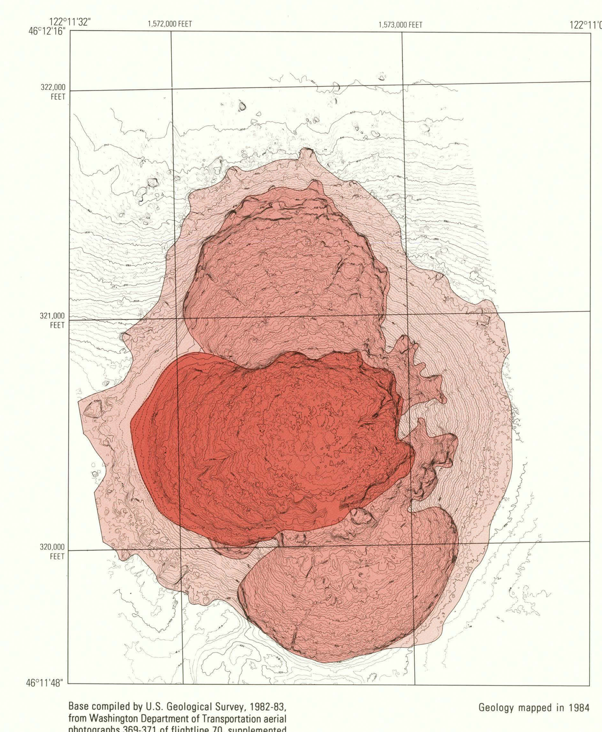
Geology mapped in 1984

Principal photography March 9, 1981
Eruption beginning February 5, 1981 (3)

Base compiled by U.S. Geological Survey, 1982-83, from Washington Department of Transportation aerial photographs 331-333 of flightline 61, supplemented by frames 328-330 of flightline 60 (April 17)
Lambert Conformal Conic projection

Geology mapped in 1984

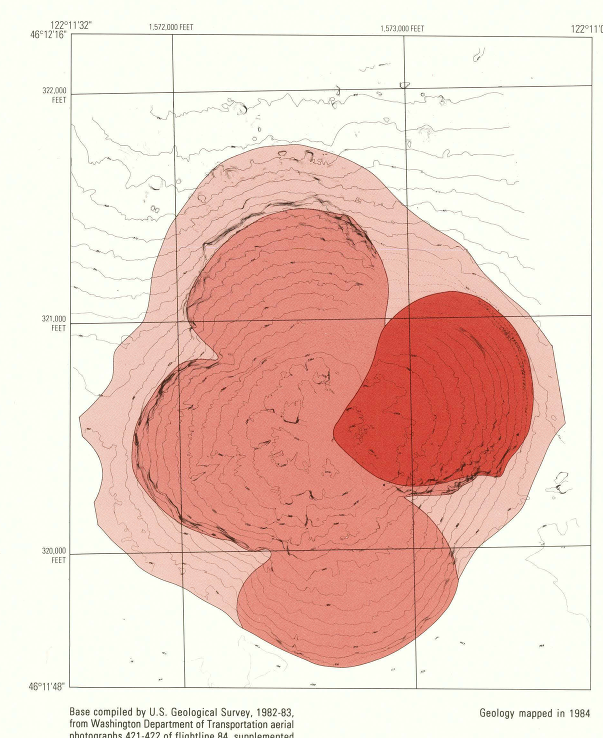
Principal photography May 8, 1981
Eruption beginning April 10, 1981 (3)



Base compiled by U.S. Geological Survey, 1982-83, from Washington Department of Transportation aerial photographs 369-371 of flightline 70, supplemented by frames 354-355 of flightline 67 (July 8)
Lambert Conformal Conic projection

Geology mapped in 1984

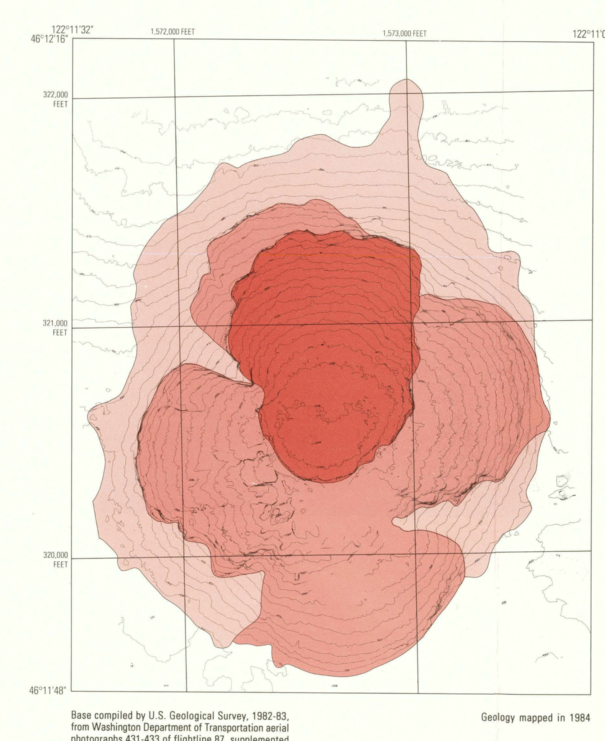
Principal photography July 31, 1981
Eruption beginning June 18, 1981 (3)



Base compiled by U.S. Geological Survey, 1982-83, from Washington Department of Transportation aerial photographs 421-422 of flightline 84, supplemented by frames 425-426 of flightline 85 (October 15) and frames 427-429 of flightline 86 (October 21)
Lambert Conformal Conic projection

Geology mapped in 1984

Principal photography October 15, 1981
Eruption beginning September 6, 1981 (5)



Base compiled by U.S. Geological Survey, 1982-83, from Washington Department of Transportation aerial photographs 431-433 of flightline 87, supplemented by frames 474-476 of flightline 98 (February 10, 1982)
Lambert Conformal Conic projection

Geology mapped in 1984

Principal photography November 4, 1981
Eruption beginning October 30, 1981 (4)

EXPLANATION

March 9, 1981
February 5, 1981 (3) **Eruptive episode**—Large type, beginning date of eruptive episode; number in parentheses, duration of eruptive episode, in days; date(s) of principal aerial photography, small type

New lobe—Lava erupted onto surface of dome since date of previous map

Old lobe(s)—Lava flows and intrusions added to dome prior to date of previous map. May be enlarged and disrupted by endogenous growth of dome

Talus—Blocky debris derived from dome and deposited on and against lower flanks

Contact—Dashed where approximately located

DISCUSSION

A composite dome of mafic dacite grew during 1980-86 in the crater that formed during a major eruption of Mount St. Helens on May 18, 1980. Five smaller explosive episodes followed between May 25 and October 18 of the same year (Moore and others, 1981). Dacite domes grew on the floor of the May 18 crater during the waning stages of three explosive episodes in June, August, and October 1980, but the June and August domes were mostly destroyed by explosions in July and October, respectively. More than a dozen additional eruptive episodes occurred between December 1980 and October 1986, but these were mostly constructive rather than destructive; each added one or more increments to the dome, which as a result became a composite edifice (Swanson and others, 1987; Swanson and Holcomb, 1990). The growth of the composite dome is summarized in this set of 18 maps. Although the growth sequence may appear simple at first sight, it was actually quite complex and produced a wide variety of features that are clearly visible if the maps are examined with care.

MAPPING PROCEDURE

In order to study its growth processes, the dome was repeatedly photographed from above at a scale of about 1:5000 and mapped at a scale of 1:2000 as it grew. The maps here are shown at a scale of 1:5000 to enhance comparison by presenting all of them together on a single sheet. The Photogrammetry Unit of the Washington Department of Transportation made vertical aerial photographs (in 9- by 9-inch color format) following most eruptive episodes and repeatedly during some of them. For most episodes, photographs were taken on more than one date because parts of the dome were obscured most days by shadows, snow, or volcanic fume. Each map was compiled using a principal set of photographs and one or more supplementary sets obtained on other days. Eruption products of August 1982 were mapped using two principal sets of photographs made on September 1 and 23, as shown on the small inset map for September 1/23, 1982. Areas persistently obscured by thick fume were never photographed well; some of these were left blank on the topographic maps, whereas others were shown using dashed lines. Topographic contours that were compiled for the lower southeastern flank of the dome from photographs of September 13, 1984 were used also for the map of August 29, 1984, since that flank did not change noticeably during the eruption of September 10.

In order to establish ground control for the maps, we maintained aerial-photograph markers on the dome and surrounding crater floor beginning in January 1981. We resurveyed the locations of the markers for each map because most of them moved during each eruptive episode. For ground surveys in 1981 we used spirit leveling and planetable triangulation from a baseline that had not been tied to the regional survey net; we obtained control for the map of October 1980 through photogrammetric comparison with the maps of January and March 1981, which were compiled earlier.

In 1981-82 Raymond Jordan compiled topographic contours for the maps of 1980-81 using an AP/C analytical plotter at the Center of Astrogeology in Flagstaff, Ariz. In 1982 N.A. Watkinson tied the local survey net within the crater of Mount St. Helens to the regional net using theodolite triangulation and electronic trilateration and fitted the previously compiled maps to the regional net using graphical methods. Subsequent maps were compiled by M.A. Thorburn at the Cascades Volcano Observatory in Vancouver, Wash., using a Kern PG-2 plotter. All topographic maps were compiled at a scale of 1:2000 with a contour interval of 2 m. The internal precision of each map probably is better than 1 m. Accuracy of the 1982-86 maps also may be better than 1 m, but the 1980-81 maps probably are less accurate owing to errors as large as several meters in fitting them to the regional survey net.

After the topographic base maps were compiled, we mapped geologic structures and contacts using a PG-2 plotter and the same photographs that had been used to map the topography. We also used supplementary photographs and field notes made by us and our colleagues (especially D.A. Swanson) during work on and around the lava dome. We were generally not able to make systematic field checks after compiling the maps, owing to time necessary for compilation, but we are confident that the maps are accurate because of the intense study given the dome during its growth. We compiled the geologic maps with much detail at a scale of 1:2000 but simplified them here to avoid obscuring the topographic information.

GROWTH PROCESSES AND MAP UNITS

These maps show how the lava dome changed in size and shape as it grew. Each growth episode following the initial extrusion of October 1980 was partially *exogenous* (lava erupted onto the surface of the dome) and partially *endogenous* (magma intruded within the dome). Both modes of growth are evident on these maps.

Exogenous growth produced lobes of newly erupted lava that were mappable on the surface of the dome; at least one such lobe is shown on each map, and two lobes are shown on a few. Most of the new lobes had steep margins and were topographically distinct, but some (such as the new lobes shown on the map of January 31, 1984) were indistinct because they were surrounded and confined by steep-sided masses of older material that they had shoved aside.

Endogenous growth resulted in expansion of the dome, with one sector commonly expanding more than others. Expansion was accommodated by stretching and cracking of the cooled carapace, jumbling its surface so that initially well-formed lobes gradually became indistinct (for example, the lobe shown on the map of September 1/23, 1982). Endogenous expansion sometimes produced distinct masses having lobe-like forms but surfaces consisting entirely of lava extruded previously (for example, the southern part of the dome on the map of July 11, 1985).

A third component of the dome was its apron of talus, a mixture derived from both newly erupted lava and older parts of the dome. This talus grew by accumulation of both single blocks and avalanches, both hot and cold. Single blocks commonly calved off flanks of the dome that were oversteepened by endogenous growth, and avalanches commonly collapsed from the margins of new lobes as they spread onto the steeper flanks. Large blocks that tumbled to the foot of the talus while hot commonly decrepitated as they cooled to form mounds or clusters of smaller blocks. Avalanches commonly produced marginal levees and distal lobes having surficial slopes less than the angle of repose. Some avalanche lobes extended northward onto the crater floor beyond the foot of the steep talus apron so as to appear morphologically distinct from the dome. Some of these deposits (for example, an extensive deposit of March 19, 1982) are excluded here from the mapped distribution of talus because they never had the appearance of being a part of the dome. Other avalanche deposits (for example, a deposit of March-April 1984) are included in some maps because their upper transitional slopes intially gave them the appearance of belonging to the dome, but they are excluded in subsequent maps owing to morphologic isolation as their upper slopes were overridden by distinctly steeper talus.

TEMPORAL VARIATIONS IN THE GROWTH PROCESS

The growth of the dome varied in character from year to year. Its initial growth of 1980-82 was dominated by eruptive episodes lasting a week or so, separated by dormant intervals of about 2 months. Each episode commenced with several days of endogenous growth, followed by exogenous growth lasting for a few days. Exogenous growth was dominant during the earliest eruptive episodes, but endogenous growth and talus development became more prominent later as the dome grew larger.

The pattern of growth changed during 1983 with a year-long interval of continuous growth from February 1983 until February 1984. Endogenous growth was dominant during this interval, with the locus of growth shifting from one part of the dome to another at intervals of 3-4 months. (These shifts are not completely documented in this set of maps.) Exogenous growth also occurred during this interval, but the lava was extruded more slowly than in previous episodes and produced various extrusive forms quite different from the lobes extruded earlier; among these newly extruded forms were ephemeral spines, conical mounds of blocky lava, and accordion-like fans of radiating ridges.

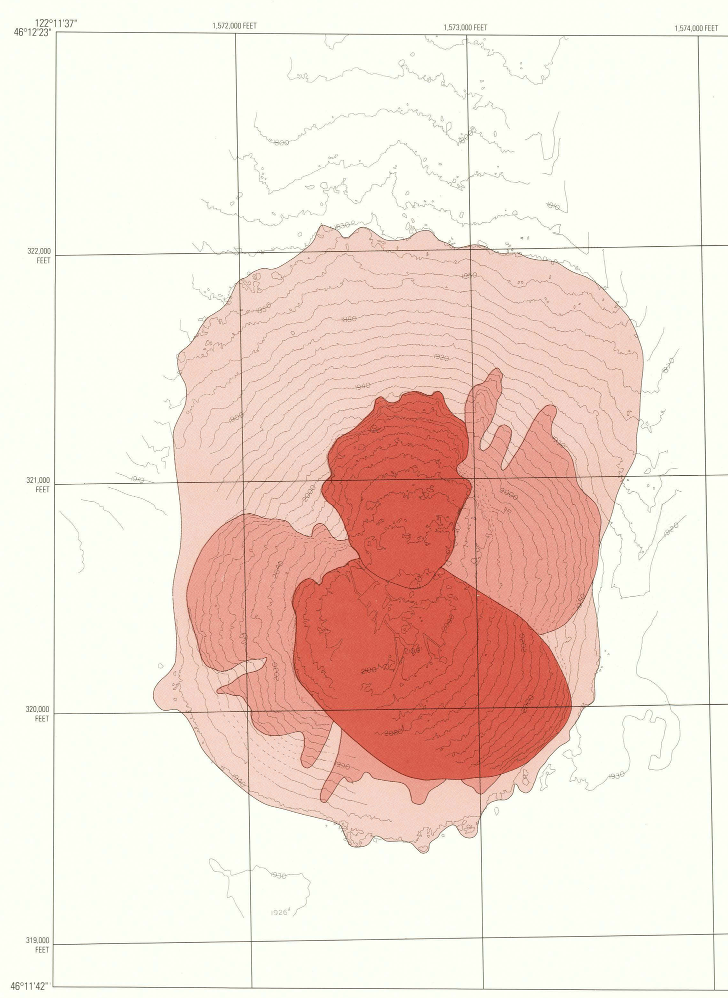
During 1984-86 the growth of the dome once again became episodic and produced rapidly extruded lobes similar to those of 1980-82. The frequency of eruptive episodes declined, however, and net growth during those episodes was dominantly endogenous, with the extruded lobes being comparatively small.

REFERENCES CITED

Moore, J.G., Lipman, P.W., Swanson, D.A., and Alpha, T.R., 1981, Growth of lava domes in the crater, June 1980-January 1981, *in* Lipman, P.W., and Mullineaux, D.R., eds., The 1980 eruptions of Mount St. Helens, Washington, U.S. Geological Survey Professional Paper 1250, p. 541-548.

Swanson, D.A., Dzurisin, D., Holcomb, R.T., Iwatsubo, E.Y., Chadwick, W.W., Jr., Casadevall, T.J., Ewert, J.W., and Heliker, C.C., 1987, Growth of the lava dome at Mount St. Helens, Washington (USA), 1981-1983, *in* Fink, J., ed., The emplacement of silicic domes and lava flows, Geological Society of America Special Paper 212, p. 1-16.

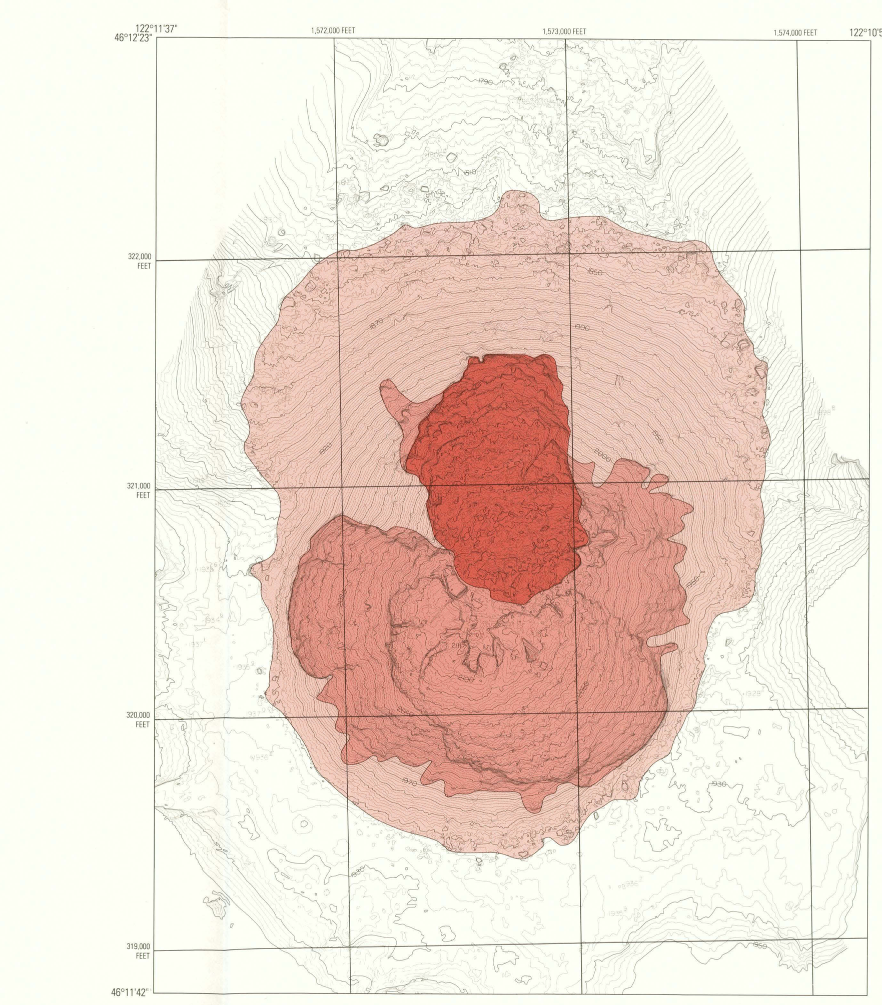
Swanson, D.A., and Holcomb, R.T., 1990, Regularities in growth of the Mount St. Helens dacite dome, 1980-1986, *in* Fink, J., ed., Lava flows and domes—emplacement mechanisms and hazard implications: New York, Springer-Verlag, p. 3-24.



Base compiled by U.S. Geological Survey, 1983, from Washington Department of Transportation aerial photographs 575-578 of flightline 112
Lambert Conformal Conic projection

Geology mapped in 1984

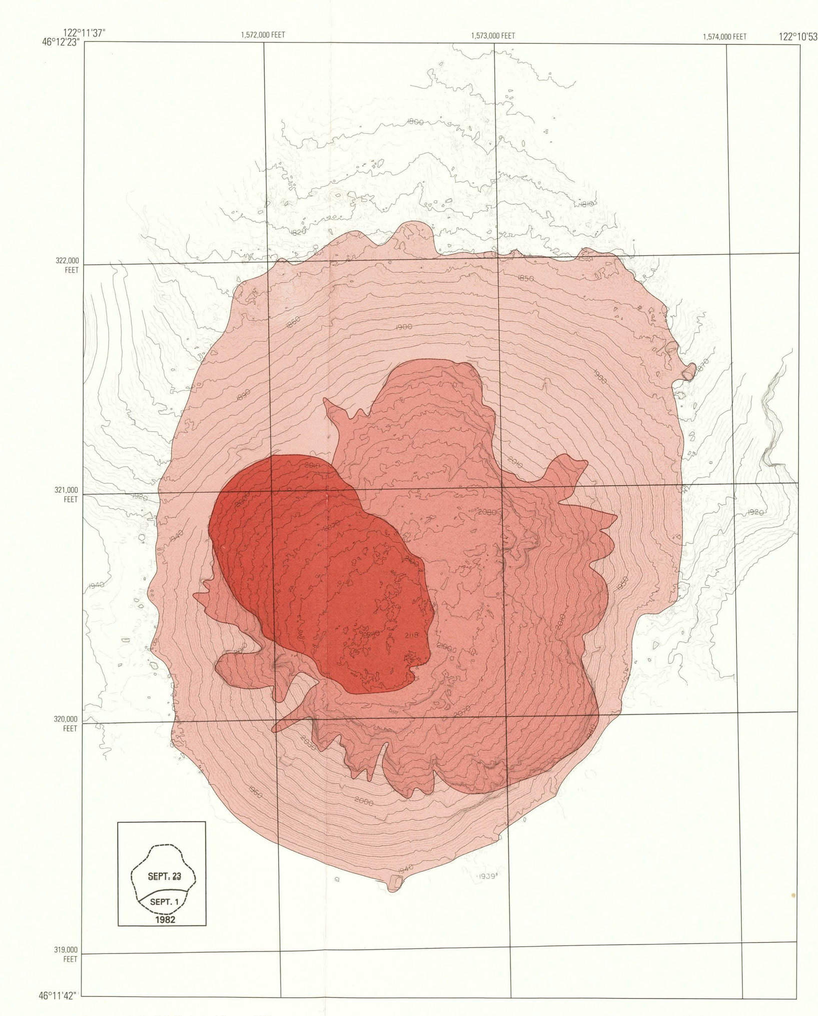
Principal photography May 13, 1982
Eruption beginning March 19, 1982 (21): southern lobe, March 20-24; northern lobe, April 6-9



Base compiled by U.S. Geological Survey, 1983, from Washington Department of Transportation aerial photographs 597-601 of flightline 116
Lambert Conformal Conic projection

Geology mapped in 1984

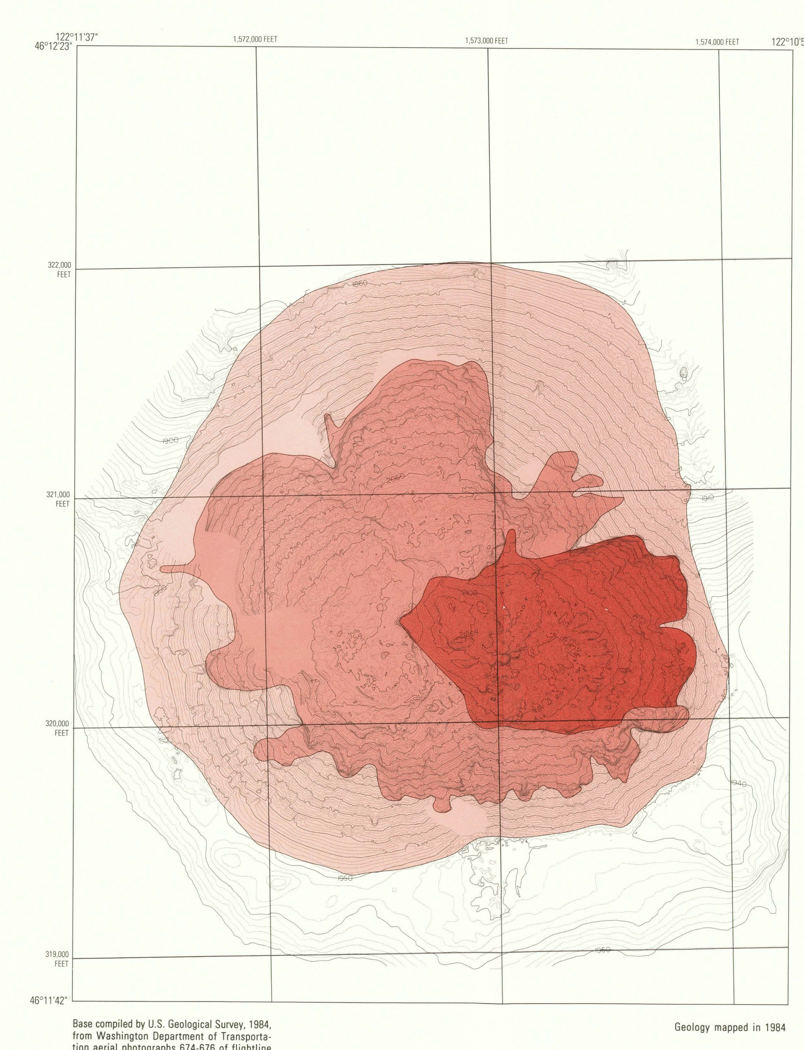
Principal photography June 23, 1982
Eruption beginning May 14, 1982 (5)



Base compiled by U.S. Geological Survey, 1983, from Washington Department of Transportation aerial photographs 619-623 of flightline 122 (September 1) and frames 648-652 of flightline 137 (September 23)
Lambert Conformal Conic projection

Geology mapped in 1984

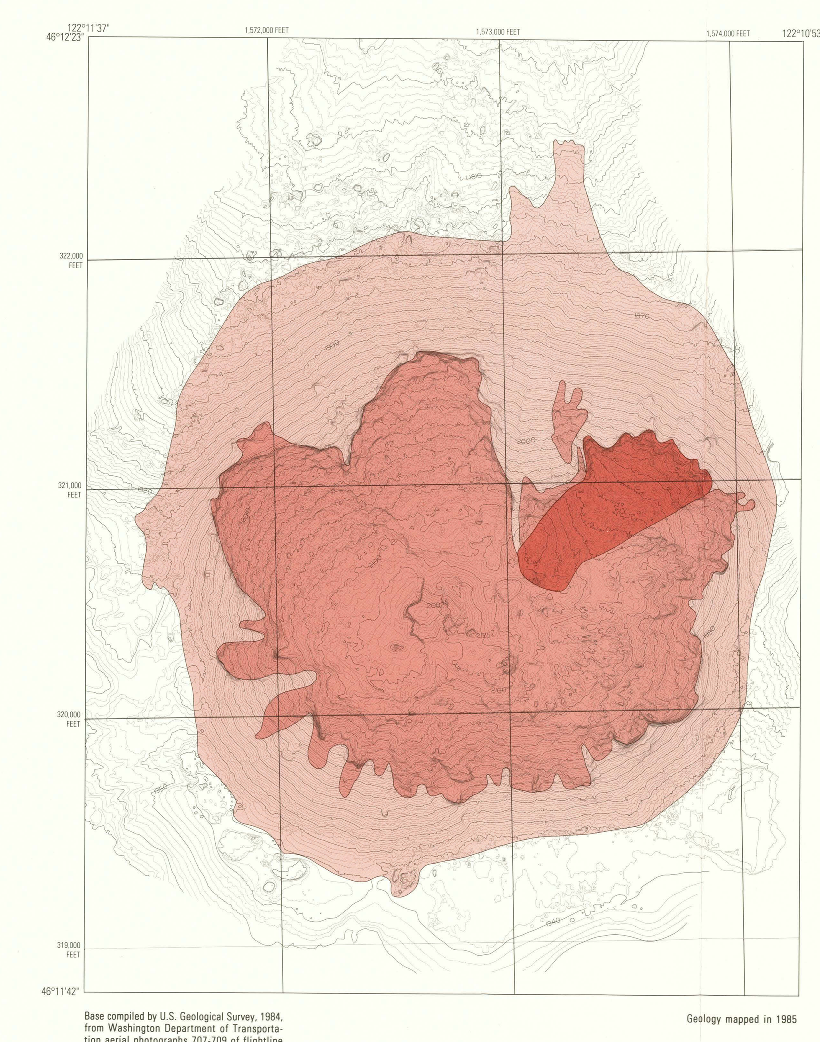
Principal photography September 1 and 23, 1982
Eruption beginning August 18, 1982 (6)



Base compiled by U.S. Geological Survey, 1984, from Washington Department of Transportation aerial photographs 674-676 of flightline 143
Lambert Conformal Conic projection

Geology mapped in 1984

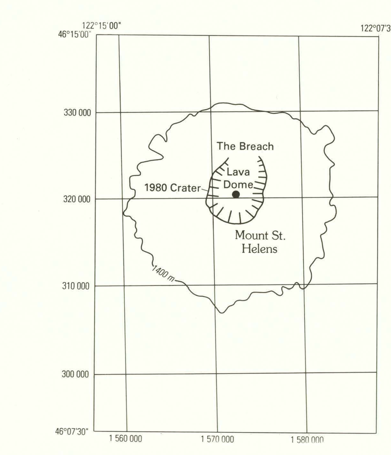
Principal photography April 15, 1983
Eruption beginning February 7, 1983 (368)
(First of three maps for this episode)



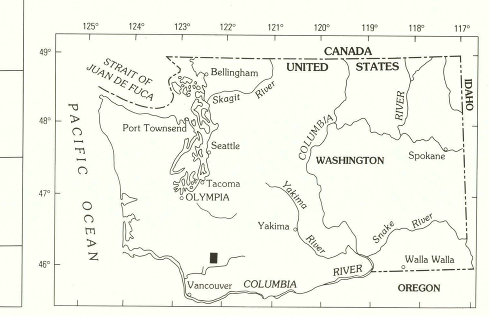
Base compiled by U.S. Geological Survey, 1984, from Washington Department of Transportation aerial photographs 707-709 of flightline 149
Lambert Conformal Conic projection

Geology mapped in 1985

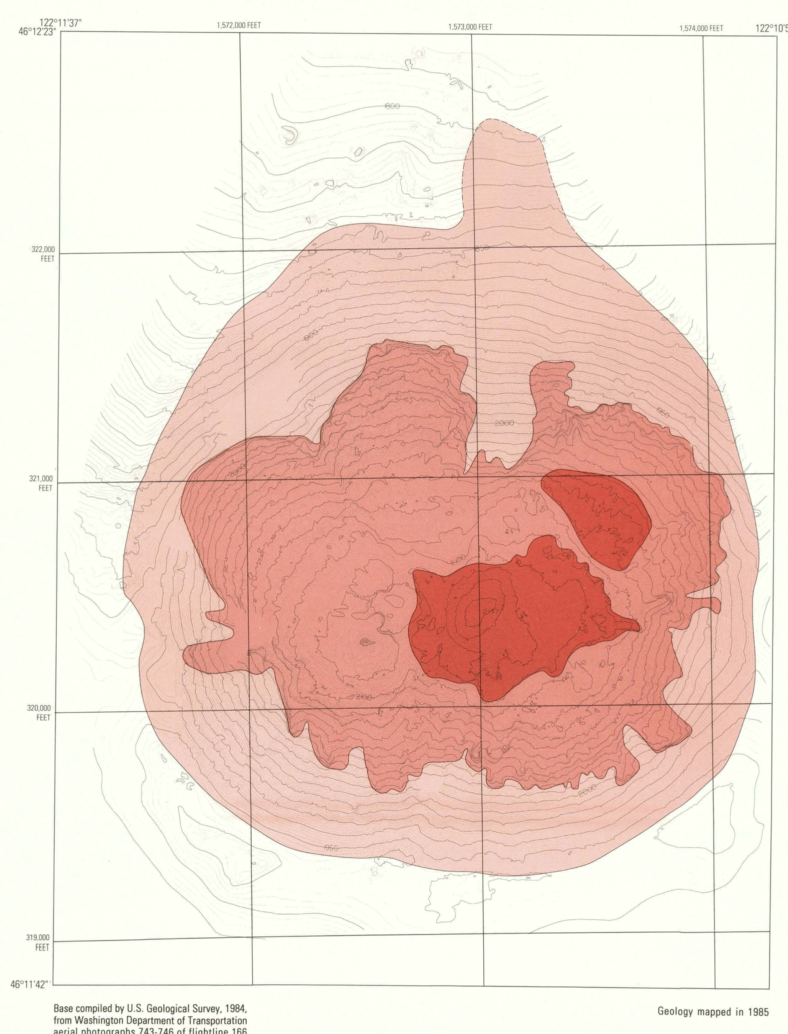
Principal photography August 17, 1983
Eruption beginning February 7, 1983 (368)
(Second of three maps for this episode)



INDEX MAP OF MOUNT ST. HELENS 7 1/2' QUADRANGLE



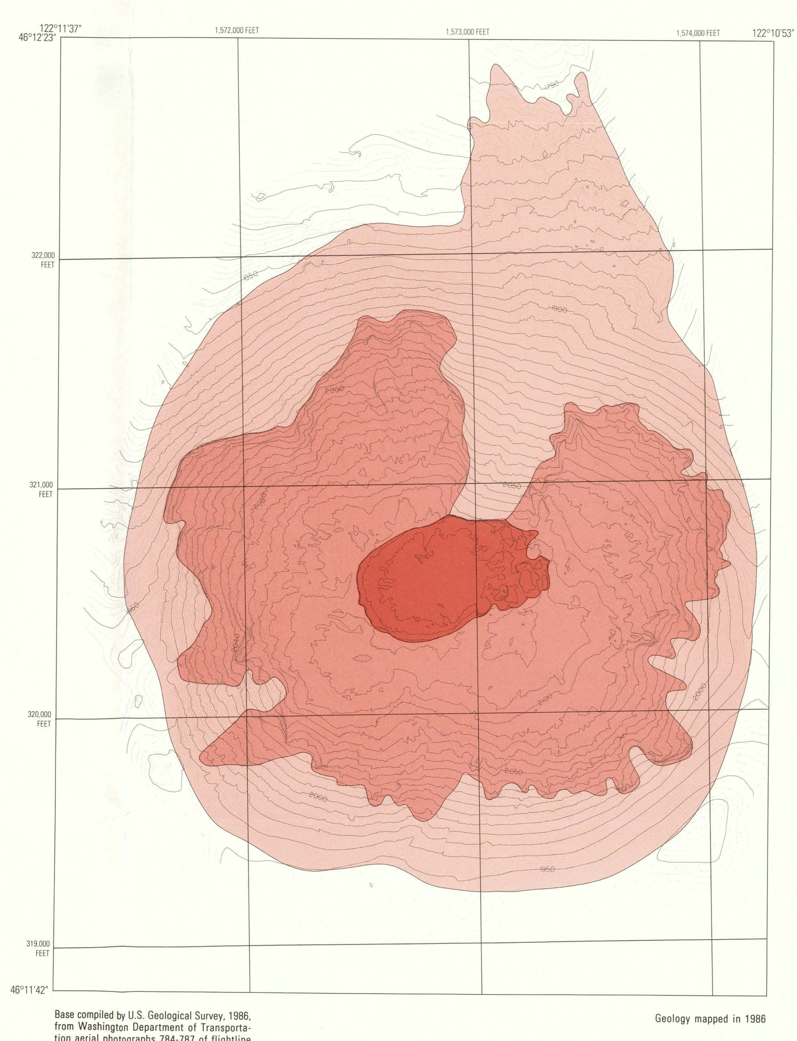
INDEX MAP OF WASHINGTON SHOWING LOCATION OF MOUNT ST. HELENS 7 1/2' QUADRANGLE (SHADED)



Base compiled by U.S. Geological Survey, 1984, from Washington Department of Transportation aerial photographs 743-746 of flightline 166
Lambert Conformal Conic projection

Geology mapped in 1985

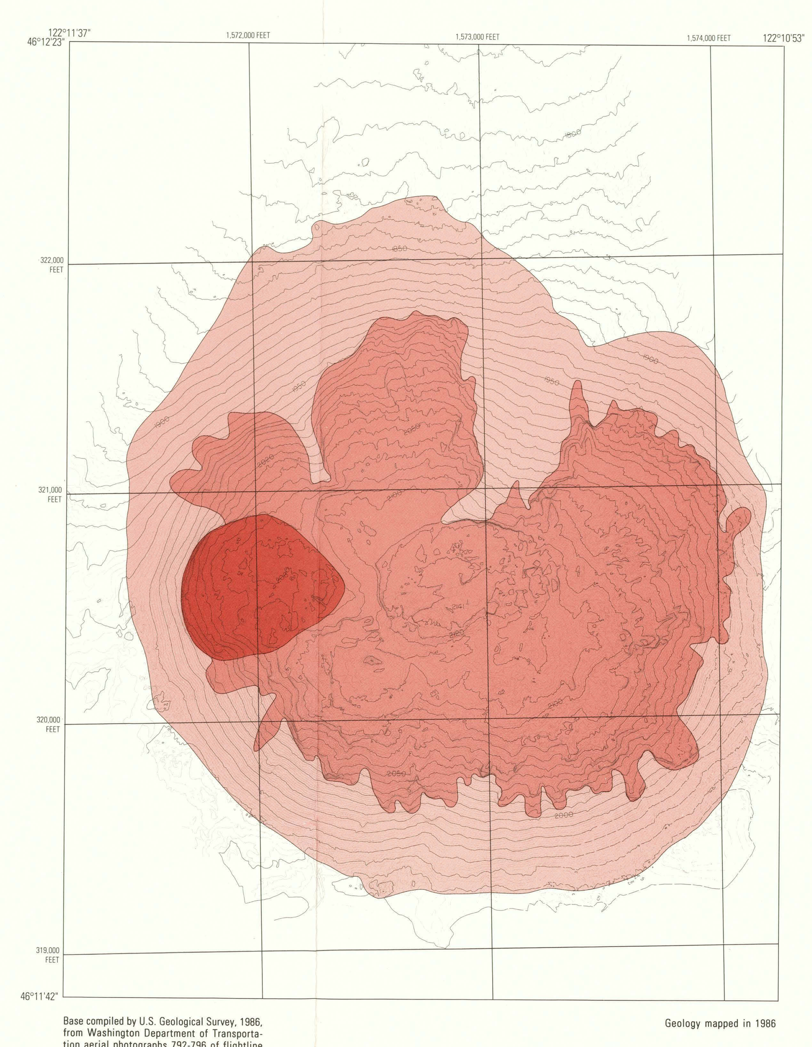
Principal photography January 31, 1984
Eruption beginning February 7, 1983 (368): northeastern lobe, August-September, southern lobe, October-January
(Third of three maps for this episode)



Base compiled by U.S. Geological Survey, 1986, from Washington Department of Transportation aerial photographs 784-787 of flightline 173
Lambert Conformal Conic projection

Geology mapped in 1986

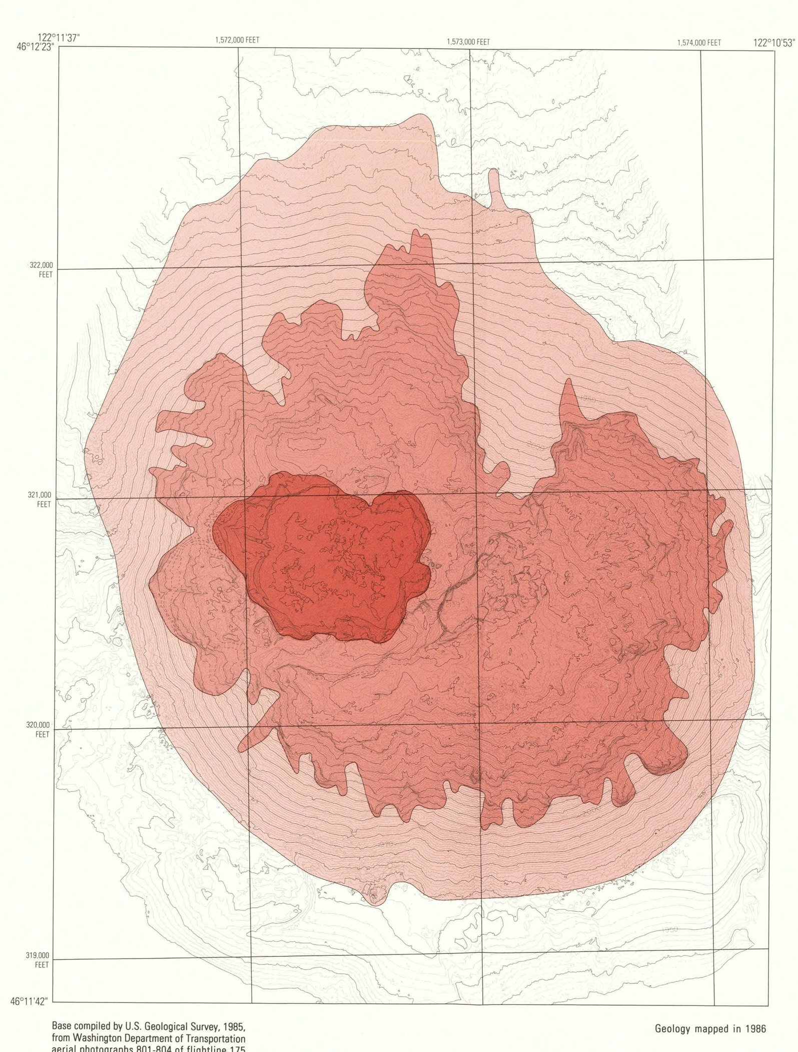
Principal photography April 14, 1984
Eruption beginning March 29, 1984 (5)



Base compiled by U.S. Geological Survey, 1986, from Washington Department of Transportation aerial photographs 792-796 of flightline 174
Lambert Conformal Conic projection

Geology mapped in 1986

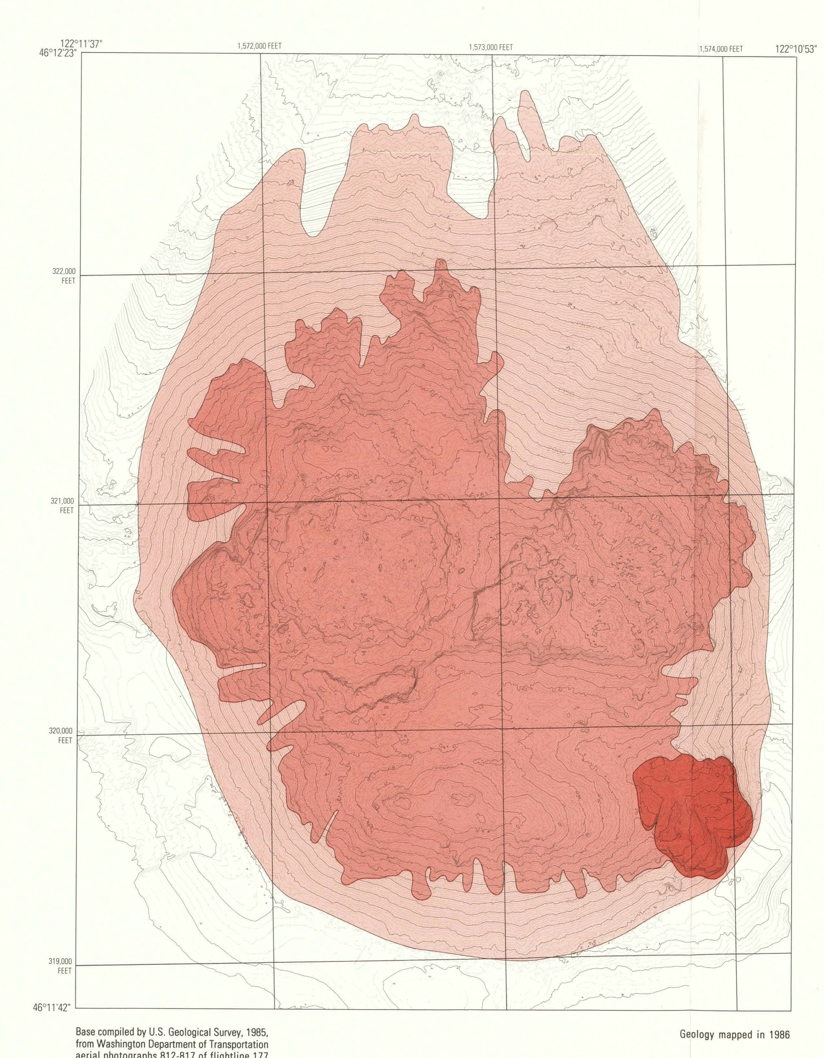
Principal photography August 29, 1984
Eruption beginning mid June, 1984 (unknown)



Base compiled by U.S. Geological Survey, 1985, from Washington Department of Transportation aerial photographs 801-804 of flightline 175
Lambert Conformal Conic projection

Geology mapped in 1986

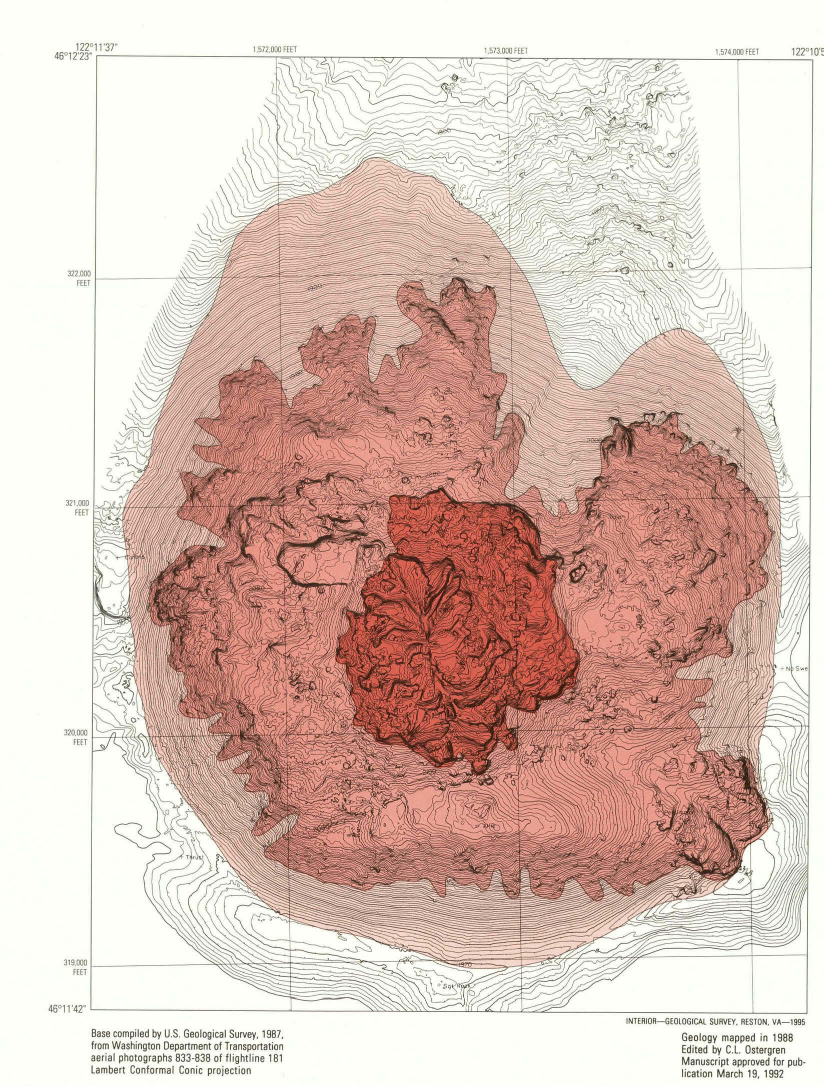
Principal photography September 13, 1984
Eruption beginning September 10, 1984 (3)



Base compiled by U.S. Geological Survey, 1985, from Washington Department of Transportation aerial photographs 812-817 of flightline 177
Lambert Conformal Conic projection

Geology mapped in 1986

Principal photography July 11, 1985
Eruption beginning May 24, 1985 (17)



Base compiled by U.S. Geological Survey, 1987, from Washington Department of Transportation aerial photographs 833-838 of flightline 181
Lambert Conformal Conic projection

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1995
Geology mapped in 1988
Edited by C.L. Ostergren
Manuscript approved for publication March 19, 1992

Aerial photographs used to compile these maps can be obtained from Photogrammetry Branch, Washington Department of Transportation, Tumwater, Washington 98501

Principal photography November 12, 1986
Eruption beginning May 8, 1986 (5) for northeastern lobe and October 21, 1986 (4) for southwestern lobe

SCALE 1:5000
200 100 0 200 400 600 METERS
400 200 0 400 800 1200 1600 2000 FEET

CONTOUR INTERVAL 2 METERS
CONTOURS DASHED WHERE UNCERTAIN
CONTOURS HACHURED IN DOWNSLOPE DIRECTION
NATIONAL GEODETIC VERTICAL DATUM OF 1929
NATIONAL GEODETIC HORIZONTAL DATUM OF 1927
10,000- AND 1000- FOOT GRID TICKS WASHINGTON STATE SOUTH ZONE

To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by 0.3048

MAPS SHOWING GROWTH OF THE LAVA DOME AT MOUNT ST. HELENS, WASHINGTON, 1980-1986

By
Robin T. Holcomb and Wayne E. Colony

1995

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U.S. Geological Survey, Information Services
Box 25286, Federal Center Denver, CO 80225