UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ANNOTATED GUIDE TO GEOLOGIC REPORTS AND MAPS OF THE GLACIER PEAK WILDERNESS AND ADJACENT AREAS, NORTHERN CASCADES, WASHINGTON

By

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Open-File Report 83-97

1983

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

CONTENTS

ILLUSTRATIONS

INTRODUCTION

This listing of reports and maps related to the geology, mineral resources, and other aspects of the Glacier Peak Wilderness and vicinity in the northern Cascade Mountains of Washington (fig. 1) was prepared as a background for 1979-82 field studies on the geology (Ford and others, 1983), regional geophysics (Flanigan and Sherrard, 1983), and geochemistry (Church and others, 1983) of the Wilderness by the U.S. Geological Survey. The studies were part of an investigation of the mineral-resource potential of the Wilderness by the Survey and the U.S. Bureau of Mines, results of which are given by Church and others (in press) and summarized by Church and Stotelmeyer (in press). Figure 2 shows areas of previous geologic mapping in and near the Wilderness. U.S. Geological Survey topographic quadrangle maps of the Wilderness are shown in figure 3. Reference citations include many on studies outside the Wilderness but on topics related to it. In general, selection of references for annotation was to provide main highlights of reports, if not given in titles, or to mention how studies of other areas relate to the geology, petrology, structure or other aspects of the Wilderness. Geologic maps of areas shown in figure 2 are generally accompanied by reports that provide many details on the geology of their areas.

ACKNOWLEDGMENTS

Reviews and addition of references by Peter Misch (University of Washington, Seattle, Wash.), Ronald B. Stotelmeyer (U.S. Bureau of Mines, Spokane, Wash.), Alan Robert Grant (Langley, Wash.), and Rowland W. Tabor and Steven M. Hodge (U.S. Geological Survey) significantly improved this bibliography on the geology of the Glacier Peak Wilderness.

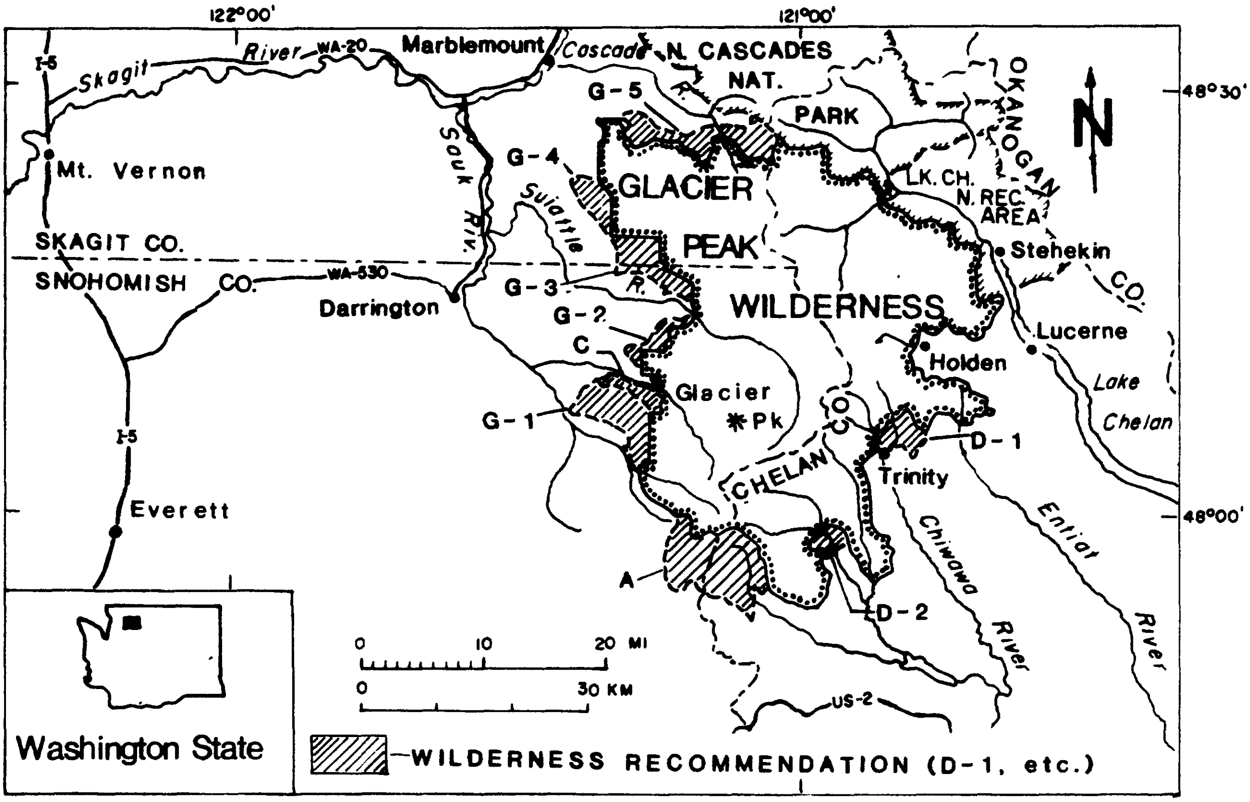

Figure 1.--Location of the Glacier Peak Wilderness.

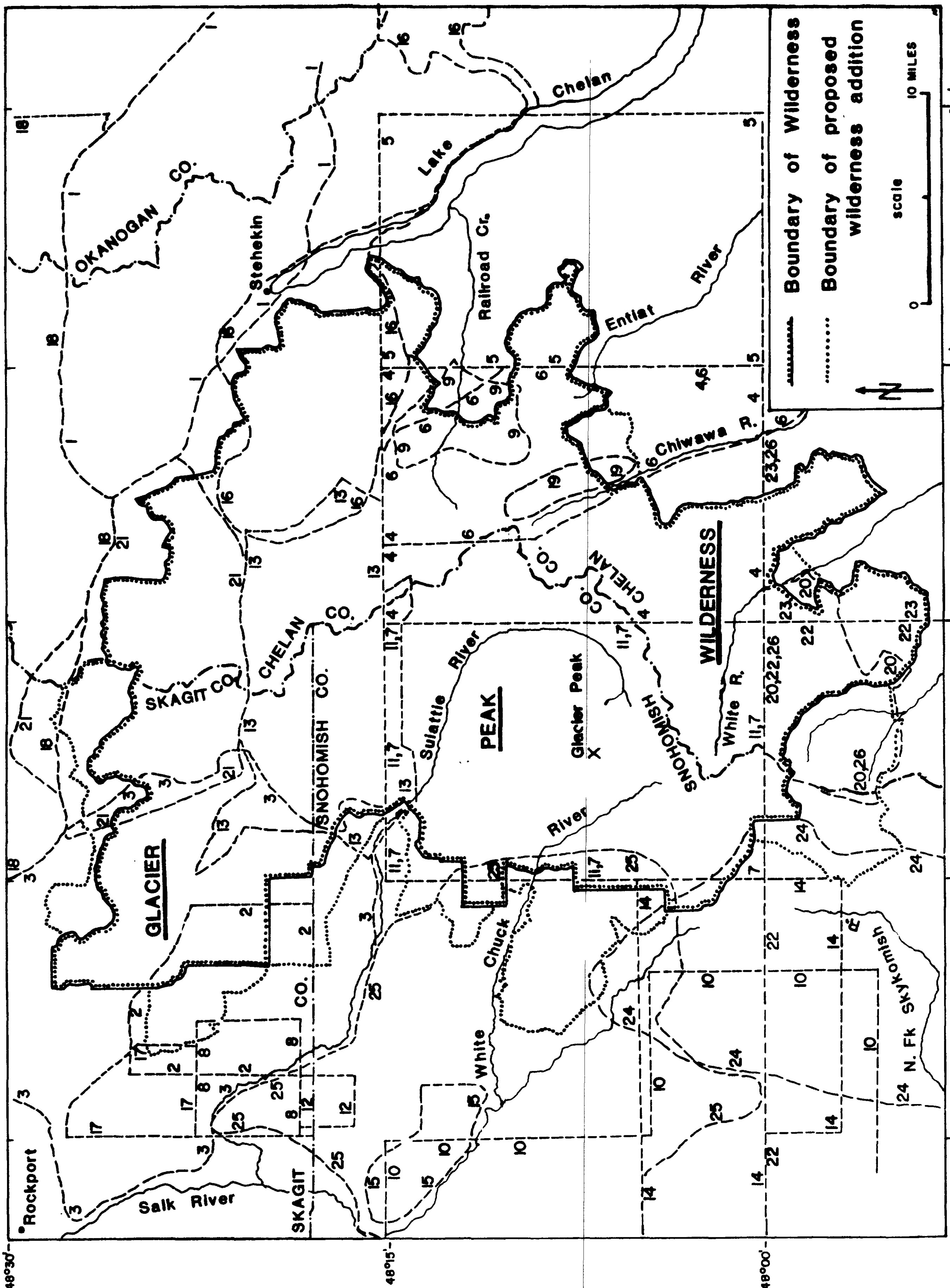
Boundary of Wilderness
Boundary of proposed wilderness addition
scale
0
10 MILES
GLACIER
PEAK
WILDERNESS
Glacier Peak
OKANOGAN CO.
SKAGIT CO.
CHELAN CO.
SNOHOMISH CO.
SKAGIT CO.
Lake Chelan
Stehekin
Railroad Cr.
Entiat River
Chiwawa R.
White R.
Suiattle River
White Chuck River
N. Fk Skykomish
Sauk River
Rockport
48°30'
48°15'
48°00'
121°30'
121°15'
121°00'
120°45'
120°30'

Figure 2.--Index to geologic mapping in and near the Glacier Peak Wilderness. Numbers inside mapped areas (dashed lines) refer to sources listed below. An additional area, the Marblemount quadrangle, mapped by Misch (1979), adjoins the western part of the index-map area on the north.

1. Adams (1961)
2. Boak (1977)
3. Bryant (1955)
4. Cater and Crowder (1967)
5. Cater and Wright (1967)
6. Crowder (1959)
7. Crowder, Tabor, and Ford (1966)
8. Dotter (1977)
9. Du Bois (1954)
10. Dungan (1974)
11. Ford (1959)
12. Franklin (1974)
13. Grant (1966)
14. Heath (1971)
15. Jenne (1978)
16. Libby (1964)
17. Milnes (1976)
18. Misch (1966)
19. Morrison (1954)
20. Rosenberg (1961)
21. Tabor (1961)
22. Tabor, Frizzell, Booth, and others (1982)
23. Tabor, Frizzell, Whetten, and others (1980)
24. Tabor, Frizzell, Yeats, and others (1982)
25. Vance (1957)
26. Van Diver (1964)

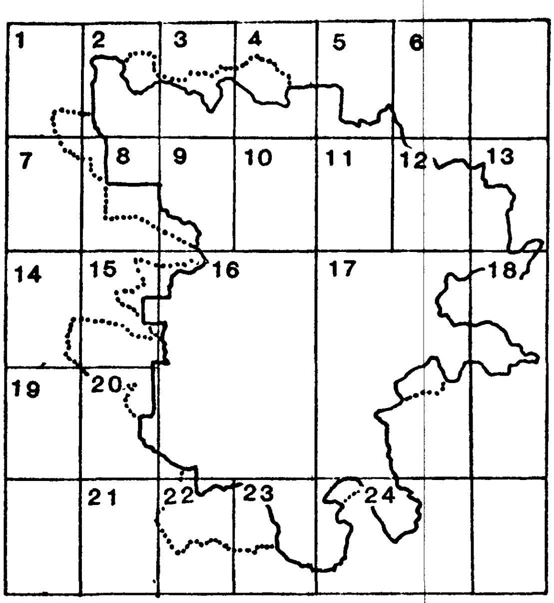

Figure 3.--Index to 1:24,000 and 1:62,500-scale topographic map quadrangles of the Glacier Peak Wilderness and vicinity. Dotted lines show proposed additions to the Wilderness.

1. Illabot Peaks 1966
2. Snowking Mtn 1966
3. Sonny Boy Lakes 1982
4. Cascade Pass 1963
5. Goode Mtn 1963
6. McGregor Mtn 1963
7. Prairie Mtn 1966
8. Huckleberry Mtn 1982
9. Downey Mtn 1963
10. Dome Peak 1963
11. Agnes Mtn 1963
12. Mt Lyall 1963
13. Stehekin 1969
14. White Chuck Mtn 1966
15. Pugh Mtn 1966
16. Glacier Peak 1950
17. Holden 1944
18. Lucerne 1944
19. Bedal 1966
20. Sloan Peak 1966
21. Blanca Lake 1965
22. Bench Mark Mtn 1965
23. Poe Mtn 1965
24. Wenatchee Lake 1965

MISCELLANEOUS TOPICS

Becky, Fred, 1977, Glacier Peak, in Cascade Alpine Guide, climbing and high routes, Stevens Pass to Rainy Pass: The Mountaineers, Seattle, Washington, p. 84-94.

Becky, Fred, and Rands, Gary, 1977, Hikers and climbers map of the Glacier Peak area of the North Cascades: The Mountaineers, Seattle, Washington.

Bennett, W. A. G., 1939, Bibliography and index of geology and mineral resources of Washington, 1814-1936: Washington (State) Division of Geology Bulletin 35, 140 p.

Crowder, D. F., and Tabor, R. W., 1965, Routes and rocks, hiker's guide to the North Cascades from Glacier Peak to Lake Chelan: The Mountaineers, Seattle, Washington, 235 p.

Manson, Connie, 1980, Theses on Washington geology--a comprehensive bibliography, 1901-1979: Washington Division of Geology and Earth Resources Information Circular 70, 212 p.

Notes: Contains maps showing locations of thesis geologic mapping.

_____1981, Index to geological and geophysical mapping of Washington: Washington Division of Geology and Earth Resources, Information Circular 73, 44 p.

Reichert, W. H., 1960, Bibliography and index of the geology and mineral resources of Washington, 1937-1956: Washington Division of Mines and Geology Bulletin 46, 721 p.

_____1969, Bibliography and index of the geology and mineral resources of Washington, 1957-1962: Washington Division of Mines and Geology Bulletin 59, 375 p.

_____1979, Index to published geologic mapping in Washington 1854-1970: Washington Division of Geology and Earth Resources, Information Circular 68, 233 p.

Wilson, Marjorie, 1958, Bibliography (Glacier Peak Wilderness): The Mountaineer, v. 51, p. 68-72.

Notes: Contains extensive listings of mostly nontechnical reports, many dealing with early history of establishing the Glacier Peak Wilderness and controversial issues involved.

GLACIER PEAK VOLCANO, VOLCANISM, AND THERMAL SPRINGS

(See listings under "Geochronology and isotope studies" for references to those subjects)

Armstrong, R. L., 1978, Cenozoic igneous history of the U.S. Cordillera from 42^{o} to 49^{o} N. latitude: Geological Society of America Memoir 152, p. 265-282.

Barnes, Ivan, 1970, Metamorphic waters from the Pacific tectonic belt of the west coast of the United States: Science, v. 168, no. 3934, p. 973-975.

Notes: Discusses compositions and occurrences, including Kennedy Hot Spring, of anomalous spring waters unusually rich in ammonia, boron, carbon dioxide, hydrogen sulfide, and hydrocarbons in more than 100 localities along the Pacific coast. Suggests that waters are products of low-grade metamorphism of marine sediments in many places tectonically emplaced beneath crystalline rocks.

Beget, J. E., 1982, Postglacial volcanic deposits at Glacier Peak, Washington, and potential hazards from future eruptions: U.S. Geological Survey Open-File Report OF 82-830, 77 p.

Notes: Detailed study of postglacial volcanic eruptions and debris flows from Glacier Peak. Deposits from pyroclastic flows, debris flows and floods reach tens of kilometers down main valleys adjoining the volcano, including from one outburst flood as recent as 1975. The record shows frequent and varied activity during late-glacial and postglacial time. The two main periods of postglacial activity are dated as (1) 11,700-11,250 yrs ago, with deposits extending to Puget Sound; and (2) 5,500-5,100 yrs ago, with deposits extending far down the Sauk, Suiattle, and Skagit Valleys. Eruptions continued until about 200-300 yrs ago. The report also discusses potential volcanic hazards.

_____1982, Recent volcanic activity at Glacier Peak: Science, v. 215, p. 1389-1390.

Notes: Brief summary of Glacier Peak volcanic activity during the past 14,000 yrs. During the past several thousand years Glacier Peak has been one of the most active Cascade volcanoes.

Berry, G. W., Grim, P. J., and Ikelman, J. A., 1980, Thermal springs list for the United States: National Oceanic and Atmospheric Administration Key to Geophysical Records Documentation No. 12, 59 p.

Notes: Contains listings with locations and temperatures for Sulphur Creek (99°F, 37°C), Gamma (140°F, 60°C) and Kennedy (100°F, 38°C) hot springs in the vicinity of Glacier Peak volcano. Copies of publication available free of charge from: NOAA/NGSDC Datamapping Group, Code D64, 325 Broadway, Boulder, CO 80303.

Blinman, Eric, 1978, Pollen analysis of Glacier Peak and Mazama volcanic ashes: Pullman, Washington State University M.A. thesis, 49 p.

Blinman, Eric, Mehringer, P. J., Jr., and Sheppard, J. C., 1977, Pollen influx and the depositional chronologies of Mazama and Glacier Peak tephra (abs.): Geological Society of America Abstracts with Programs, v. 9, no. 7, p. 901-902.

Carithers, Ward, 1946, Pumice and pumicite occurrences of Washington: Washington Division of Mines and Geology Report of Investigations 15, 78 p.

Czamanske, G. K., and Porter, S. C., 1965, Titanium dioxide in pyroclastic layers from volcanoes in the Cascade Range: Science, v. 150, no. 3699, p. 1022-1025.

Notes: Evaluates use of TiO_2 content to correlate pyroclastic units from Cascade volcanoes, including Glacier Peak. TiO_2 content of volcanic ashes reflects chemical differences in parental magmas. The method might prove useful for distinguishing several major ash layers, but not all, from Mt. St. Helens, Glacier Peak, and Mt. Mazama.

Ford, A. B., 1959, Geology and petrology of the Glacier Peak quadrangle, northern Cascades, Washington: Seattle, Washington University Ph.D. thesis, 337 p.

Notes: Contains first description of Glacier Peak volcanic rocks and of pyroclastic deposits of upper Suiattle and White Chuck River valleys, and postglacial cinder cones south of Glacier Peak.

Fryxell, Roald, 1965, Mazama and Glacier Peak volcanic ash layers--relative ages: Science, v. 147, p. 1288-1290.

Notes: A radiocarbon age of about 12,000 yrs confirms geologic evidence that ash from a Glacier Peak eruption is substantially older than ash from Mt. Mazama (6,600 yrs).

Hopson, C. A., Crowder, D. F., Tabor, R. W., Cater, F. W., and Wise, W. S., 1966, Association of andesitic volcanoes in the Cascade Mountains with Late Tertiary epizonal plutons (abs.) _in_ Abstracts for 1965: Geological Society of America Special Paper 87, p. 80.

Hughes, J. M., Stoiber, R. E., and Carr, M. J., 1980, Segmentation of the Cascade volcanic chain: Geology, v. 8, p. 15-17.

Notes: Volcano alinements divide the Cascade volcanic chain (northern California to British Columbia) into six segments averaging 175 km long. Glacier Peak, classed as a "divergent volcano", lies on a segment boundary.

Lemke, R. W., Mudge, M. R., Wilcox, R. E., and Powers, H. A., 1975, Geologic setting of the Glacier Peak and Mazama ash-bed markers in west-central Montana: U.S. Geological Survey Bulletin 1395-H, 26 p.

Majors, H. M., 1980, The first reference to Glacier Peak and its activity: Northwest Discovery, v. 1, no. 2, p. 109.

Notes: Report by native Indians (to pioneer naturalist, George Cribbs) that they observed Glacier Peak had "smoked" in the recent past.

Mariner, R. H., Presser, T. S., and Evans, W. C., 1982, Chemical and isotopic composition of water from thermal and mineral springs of Washington: U.S. Geological Survey Open-File Report 82-98, 18 p.

Notes: Contains data for Gamma, Kennedy, and Sulphur Hot Springs in the vicinity of Glacier Peak. Gamma is the hottest (65°C, 149°F) thermal spring in Washington State, and temperatures for Kennedy are 35°C (95°F) and for Sulphur are 37°C (99°F). Note differences for Gamma and Kennedy given by Berry and others (1980). See listing under heading "Mineral deposits and resource studies" for additional comments.

McBirney, A. R., 1978, Volcanic evolution of the Cascade Range: Annual Review of Earth and Planetary Sciences, v. 6, p. 437-456.

Notes: Reviews chiefly Quaternary development and trends of magmatic evolution of Cascade volcanoes: a general discussion, with little specific mention of Glacier Peak. Concludes that there is little direct relation, other than a somewhat ambiguous spatial one, between Cascade volcanism and the Pacific margin subduction commonly proposed to be asociated with it.

McBirney, A. R., and White, C. M., 1982, The Cascade province, in Thorpe, R. S., ed., Andesites: New York, John Wiley & Sons, p. 115-135.

Notes: Account similar to that by McBirney (1978). Authors conclude that the ultimate cause of andesitic volcanism in the Cascade province is still unknown.

Porter, S. C., 1976, Stratigraphy and distribution of tephra from Glacier Peak (of 12,000 years ago) in the North Cascade Range, Washington: U.S. Geological Survey Open-File Report OF-76-186.

_____1977, Relationship of Glacier Peak tephra eruptions to late-glacial events in the north Cascade Range, Washington (abs.): Geological Society of America Abstracts with Programs, v. 9, no. 7, p. 1132.

_____1978, Glacier Peak tephra in the North Cascade Range, Washington--stratigraphy, distribution, and relationship to late-glacial events: Quaternary Research, v. 10, p. 30-41.

Powers, H. A., and Wilcox, R. E., 1964, Volcanic ash from Mount Mazama (Crater Lake) and from Glacier Peak: Science, v. 144, p. 1334-1336.

Rigg, G. B., and Gould, H. R., 1957, Age of Glacier Peak eruption and chronology of post-glacial peat deposits in Washington and surrounding areas: American Journal of Science, v. 255, no. 5, p. 341-363.

Russell, I. C., 1900, A preliminary paper on the geology of the Cascade Mountains: U.S. Geological Survey 20th Annual Report, pt. 2, p. 83-210.

Notes: Early traverses across northern Cascades, with first description, as far as known to present author, of the volcano of Glacier Peak.

Smith, H. W., and Okazaki, Rose, 1977, Electron microprobe data for tephra attributed to Glacier Peak, Washington: Quaternary Research, v. 7, p. 197-206.

Steen, V. C., 1965, Effects of weathering environment on the refractive index of pumice glass from Glacier Peak, Washington, and Mount Mazama (Crater Lake), Oregon: Pullman, Washington State University M.S. thesis, 147 p.

Steen, V. C., and Fryxell, Roald, 1965, Mazama and Glacier Peak pumice glass--uniformity of refractive index after weathering: Science, v. 150, p. 878-880.

Tabor, R. W., and Crowder, D. F., 1969, On batholiths and volcanoes--intrusion and eruption of late Cenozoic magma in the Glacier Peak area, North Cascades, Washington: U.S. Geological Survey Professional Paper 604, 67 p.

Notes: Detailed description of Glacier Peak volcano and the petrology and mineralogy of its lavas, most of which are dacitic in composition. Provides numerous chemical analyses of the eruptive rocks. Distinguishes them from older volcanic rocks of possible Miocene or Pliocene age on Gamma Ridge.

Tucker, G. B., 1977, Morphologic parameters of Mount Mazama and Glacier Peak tephras--a scanning-electron microscope study: Seattle, Washington University M.S. thesis, 108 p.

Vance, J. A., 1957, The geology of the Sauk River area in the northern Cascades of Washington: Seattle, Washington University Ph.D. thesis, 312 p.

Notes: Describes ash-fill terraces of the lower Suiattle, White Chuck, and Sauk Rivers related to a major Recent eruption of Glacier Peak volcano. The terraces unconformably overlie the youngest Pleistocene deposits in the area. Ash carried by the White Chuck and Sauk Rivers was deposited in a large fan near Darrington that extended far westward down the valley of North Fork of the Stillaguamish River. The Sauk was later diverted to flow northward into the Skagit River. The Sauk Prairie surface was built as a smaller similar fan by the Suiattle River.

Westgate, J. A., and Evans, M. E., 1978, Compositional variability of Glacier Peak tephra and its stratigraphic significance: Canadian Journal of Earth Sciences, v. 15, p. 1554-1567.

Wilcox, R. E., 1959, Some effects of recent volcanic ash falls with especial reference to Alaska: U.S. Geological Survey Bulletin 1028-N, p. 409-476.

_____1969, Airfall deposits of two closely spaced eruptions in late glacial time from Glacier Peak volcano, Washington: Geological Society of America Abstracts with Programs, 1969, pt. 5, p. 88-89.

QUATERNARY GEOLOGY AND GLACIER STUDIES

(See also Glacier Peak volcano listings)

Beget, J. E., 1981, Early Holocene glacier advance in the North Cascade Range, Washington: Geology, v. 9, p. 409-413.

Hodge, S. M., 1974, Variations in the sliding of a temperate glacier: Journal of Glaciology, v. 13, no. 69, p. 349-369.

_____1976, Direct measurement of basal water pressures: a pilot study: Journal of Glaciology, v. 16, no. 74, p. 205-218.

Notes: Bore-hole drilling of South Cascade Glacier for study of long-term trend in bore-hole water levels supports the idea of seasonal storage and release of liquid water.

_____1979, Direct measurement of basal water pressures: progress and problems: Journal of Glaciology, v. 23, no. 89, p. 309-319.

Jacobel, R. W., 1982, Short-term variations in velocity of South Cascade Glacier, Washington, U.S.A.: Journal of Glaciology, v. 28, no. 99, p. 325-332.

Krimmel, R. M., 1968, Gravimetric ice thickness determination, South Cascade Glacier, Washington: Tacoma, University Puget Sound B.S. thesis, 9 p.

_____1971, Gravimetric ice thickness determination, South Cascade Glacier, Washington (abs.): EOS, v. 52, no. 5, p. 434.

Krimmel, R. M., and Tangborn, W. V., 1974, South Cascade Glacier: the moderating effect of glaciers on runoff: Proceedings of the Western Snow Conference, 42nd annual meeting, 1974, p. 9-13.

Meier, M. F., 1958, Research on the South Cascade Glacier: The Mountaineer, v. 51, p. 40-47.

_____1961, Mass budget of South Cascade Glacier, 1957-60: U.S. Geological Survey Professional Paper 424-B, p. B206-B211.

_____1966, Some glaciological interpretations of remapping programs on South Cascade, Nisqually, and Klawatti Glaciers, Washington: Canadian Journal of Earth Sciences, v. 3, no. 6, p. 811-18.

Meier, M. F., Alexander, R. H., and Campbell, W. J., 1966, Multispectral sensing tests at South Cascade Glacier, Washington, _in_ Proceedings of the 4th symposium on remote sensing of environment: Ann Arbor, Willow Run Laboratories, Institute of Science and Technology, University of Michigan, p. 145-59.

Meier, M. F., and Tangborn, W. V., 1965, Net budget and flow of South Cascade Glacier, Washington: Journal of Glaciology, v. 5, no. 41, p. 547-66.

Meier, M. F., Tangborn, W. V., Mayo, L. R., and Post, A., 1971, Combined ice and water balances of Gulkana and Wolverine Glaciers, Alaska, and South Cascade Glacier, Washington, 1965 and 1966 hydrologic years: U.S. Geological Survey Professional Paper 715-A, 23 p.

Miller, C. D., 1967, Chronology of neoglacial moraines in the Dome Peak area, north Cascade Range, Washington: Seattle, Washington University M.S. thesis, 37 p.

____1969, Chronology of Neoglacial moraines in the Dome Peak area, north Cascade Range, Washington: Arctic and Alpine Research, v. 1, no. 1, p. 49-66.

Nimick, D. A., 1977, Glacial geology of Lake Wenatchee and vicinity, Washington: Seattle, Washington University M.S. thesis, 52 p.

Post, Austin, Richardson, Don, Tangborn, W. V., and Rosselot, F. L., 1971, Inventory of glaciers in the North Cascades, Washington: U.S. Geological Survey Professional Paper 705-A, 26 p.

Notes: Listings include each glacier's location, drainage basin, area, length, orientation, altitude and classification. The report contains excellent photographs showing glaciers on the east side of Glacier Peak (Chocolate and North Guardian Glaciers), on the eastern side of Dome Peak (Chickamin Glacier), and south side of Glacier Peak (White Chuck Glacier). The active Chocolate Glacier advanced about 400 m in 1950-1955 and showed little change since then. The North Guardian Glacier advanced 140 m between 1956 and 1968. The White Chuck Glacier retreated 430 m in 1949-67 and is now nearly stagnant.

Tangborn, W. V., 1962, Glaciological investigations on South Cascade Glacier: The Mountaineer (Seattle), v. 55, no. 4, p. 24-32.

Tangborn, W. V., Krimmel, R. M., and Meier, M. F., 1975, A comparison of glacier mass balance by glaciologic, hydrologic, and mapping methods, South Cascade Glacier, Washington: International Association of Hydrologic Sciences, Moscow General Assembly 1971, IAHS-AISH Pub. 104, p. 185-196.

Tangborn, W. V., Mayo, L. R., Scully, D. R., and Krimmel, R. M., 1977, Combined ice and water balances of Maclure Glacier, California, South Cascade Glacier, Washington, and Wolverine and Gulkana Glaciers, Alaska, 1967 hydrologic year: U.S. Geological Survey Professional Paper 715-B, 20 p.

Notes: South Cascade Glacier had a 1967 winter balance of 3.28 m, slightly above average. Above-normal summer ablation resulted in a final annual balance of -0.58 m, slightly more negative than for the past decade.

Watts, R. D., England, A. W., Vickers, R. S., and Meier, M. F., 1975, Radio-echo sounding on South Cascade Glacier, Washington, using a long-wavelength, mono-pulse source (abs.): Journal of Glaciology, v. 15, no. 73, p. 459-461.

Willis, Bailey, 1903, Physiography and deformation of the Wenatchee-Chelan district, Cascade Range: U.S. Geological Survey Professional Paper 19, p. 41-97.

Notes: Contains early (1895-1900) observations and inferences on the physiographic development of the northern Cascades in the vicinity of the Glacier Peak Wilderness. Recognizes five stages of physiographic development and two stages of deformation, associated with uplift, from Pliocene to Recent time.

REGIONAL GEOLOGY AND GEOLOGIC SETTING

(See figure 2 for location of geologic mapping near Glacier Peak Wilderness)

Adams, J. B., 1958, Petrology of the isochemically metamorphosed rocks in the McGregor Mountain area, Chelan County, Washington: Seattle, Washington University M.S. thesis, 49 p.

_____1961, Petrology and structure of the Stehekin-Twisp Pass area, northern Cascades, Washington: Seattle, Washington University Ph.D. thesis, 172 p. (Fig. 2)

_____1964, Origin of the Black Peak Quartz Diorite, northern Cascades, Washington: American Journal of Science, v. 262, p. 290-306.

Notes: Based on thesis studies (Adams, 1958 and 1961, above) of area lying immediately northeast of the Glacier Peak Wilderness, shows continuation of the Skagit Gneiss eastward from the Stehekin River valley and gradational changes into the Black Peak Quartz Diorite having typical igneous-appearing textures.

Armstrong, R. L., 1978, Cenozoic igneous history of the U.S. Cordillera from 42° to 49° N. latitude: Geological Society of America Memoir 152, p. 265-282.

Daly, R. A., 1912, Geology of the North American Cordillera at the forty-ninth parallel: Canada Geological Survey Memoir 38, 857 p.

Notes: An early reconnaissance geological survey, in 1901-06, of 5-10-mile-wide area along the Canadian border, during which some of the major rock units of the northern Cascades were first recognized.

Dungan, M. A., 1974, The origin, emplacement, and metamorphism of the Sultan mafic-ultramafic complex, North Cascades, Snohomish County, Washington: Seattle, Washington University Ph.D. thesis, 227 p.

Notes: Contains geologic map of area about 4 mi. west of Glacier Peak Wilderness. (Fig. 2)

Franklin, W. E., 1974, Structural significance of meta-igneous fragments in the Prairie Mountain area, North Cascade Range, Snohomish County, Washington: Corvallis, Oregon State University M.S. thesis, 109 p.

Notes: Contains geologic map of area lying about 2 miles west of recommended Wilderness addition. (Fig. 2)

Gresens, R. L., 1982, Early Cenozoic geology of Central Washington State: II. implications for plate tectonics and alternatives for the origin of the Chiwaukum graben: Northwest Science, v. 56, no. 4, p. 259-264.

Notes: Discusses two possible origins of the Chiwaukum graben, the northern apex of which lies near the southeast border of Glacier Peak Wilderness: (1) by a combination of strike-slip motion and clockwise rotation; and (2) a preferred model, by development of a pull-apart basin, or "rhombochasm," related to right-lateral strike-slip movements on the Entiat fault, the east-bounding fault of the graben. Cessation of graben activity about 40 m.y. ago coincides with ending of western North American Laramide deformation and global reorganization of plate motions.

Huntting, M. T., Bennett, W. A. G., Livingston, V. S., and Moen, W. S., 1961, Geologic map of Washington (scale 1:500,000): Washington Department of Natural Resources; Division of Mines and Geology.

Jenne, D. A., 1978, Structural geology and metamorphic petrology of the Gold Mountain area, Snohomish County, Washington: Corvallis, Oregon State University M.S. thesis, 177 p.

Notes: Contains geologic map of area lying about 5 miles west of recommended Wilderness addition. (Fig. 2)

McTaggart, K. C., and Thompson, R. M., 1967, Geology of part of the northern Cascades in southern British Columbia: Canadian Journal of Earth Sciences, v. 4, no. 6, p. 1199-1228.

Notes: Discusses origin, by metamorphism of Hozameen Group rocks, of the Custer Gneiss and its correlation with the Skagit Gneiss of Misch (1966), a unit present in the eastern part of Glacier Peak Wilderness. Area contains gneissic tonalite bodies (Spuzzum intrusions) very similar in age and lithology to units (Tenpeak and Sloan Creek plutons) in the Wilderness.

Misch, Peter, 1952, Geology of the northern Cascades of Washington: Mountaineer, v. 45, no. 12, p. 4-22.

Notes: Contains first reconnaissance geologic sketch map, based on 1949-52 mapping, of the northern Cascades from the Cascade and Stehekin River valleys to the Canadian border; and first usage of names of units (including "Skagit gneisses, Marblemount quartz diorite, and Shuksan greenschist") that extend southward into the vicinity of the Glacier Peak Wilderness.

_____1964, Crystalline basement complex in northern Cascades of Washington (abs.), in Abstracts for 1963: Geological Society of America Special Paper 76, p. 213-214.

_____1966, Tectonic evolution of the northern Cascades of Washington State--A west-Cordilleran case history, in Symposium on tectonic history and mineral deposits of the western Cordillera in British Columbia and in neighboring parts of the U.S.A.: Canadian Institute of Mining and Metallurgy, Special Volume 8, p. 101-148.

Notes: Contains updated version of above-mentioned (1952) geologic map (scale, 1 in. = approx. 9 mi.) of the northern Cascades and shows the following major map units named by Misch that project southward or southeastward into the area of the Glacier Peak Wilderness: from west to east, Shuksan Greenschist (west of the Straight Creek fault, others east)

Cascade River Schist, Marblemount Meta-Quartz Diorite, Eldorado Orthogneiss, and Skagit Gneiss. The report also names and discusses structural relations of the Magic Mountain Gneiss--a diaphthoritic gneiss unit thrust eastward from a root zone in the belt of Marblemount Meta-Quartz Diorite in the northern part of the Wilderness area. This is the most complete available report describing the geologic history, including metamorphism, of many of the rock units of the Wilderness. Of particular interest regarding age of faulting on the Straight Creek fault (west edge of the Wilderness), Misch's mapping shows the northward extension of the fault to be truncated by the Chillwack Composite Batholith of late Eocene to early Oligocene age. (Fig. 2)

_____1971, Metamorphic facies types in north Cascades (abs.): Geological Society of Canada, Cordilleran Section, Symposium on Metamorphism in Canadian Cordillera, Program, p. 22-23.

_____1973, The North Cascades in geotectonic perspective (abs.): Geological Society of America Abstracts with Programs, v. 5, no. 1, p. 82.

_____1977, Dextral displacements at some major strike faults in the North Cascades (abs.): Geological Association of Canada 1977 annual meeting, Program with Abstracts, p. 37.

Notes: Recognizes very large amount of dextral (right lateral) slip on faults, including the Straight Creek fault.

_____1979, Geologic map of the Marblemount quadrangle, Washington (1:48,000 scale): Washington Division of Geology and Earth Resources Geologic Map GM-23.

Notes: Area lies immediately north of that shown in Plate 1. The map shows continuation of schist and gneiss units northwestward from the Glacier Peak Wilderness vicinity to the Skagit Valley region, and shows continuation of the Straight Creek fault northward to where it is cut by granitoid rocks of the late Eocene to early Oligocene Chilliwack Composite Batholith.

_____1982, North Cascades geology (abs.): Geological Society of America Abstracts with Programs, v. 14, no. 4, p. 217.

Russell, I. C., 1900, A preliminary paper on the geology of the Cascade Mountains: U.S. Geological Survey 20th Annual Report, pt. 2, p. 83-210.

Notes: Early traverses across northern Cascades, including White and Sauk Rivers between Lake Wenatchee and Darrington. Contains colored geologic sketch map of routes. First description, as far as known to present author, of the volcano and volcanic rocks of Glacier Peak.

Tabor, R. W., Zartman, R. E., and Frizzell, V. A., Jr., 1982, Possible accreted terranes in the North Cascade crystalline core, WA (abs.): Geological Society of America Abstracts with Programs, v. 14, no. 4, p. 239.

Tipper, H. W., Woodsworth, G. J., and Gabrielse, H., 1981, Tectonic assemblage map of the Canadian Cordillera and adjacent parts of the United States of America (scale 1:2,000,000): Geological Survey of Canada Map 1505A.

Notes: Map area extends southward from Canadian border and includes most of area of Glacier Peak Wilderness.

Vance, J. A., 1979, Early and middle Cenozoic arc magmatism and tectonics in Washington State (abs.): Geological Society of America, Abstracts with Programs, v. 11, no. 3, p. 132.

Notes: The Washington Cascades comprise two overlapping Cenozoic magmatic arcs, one (Challis arc) of Eocene age and the other (Cascade arc) beginning in the early Oligocene. Development of the Chiwaukum graben (Willis, 1953; Gresens, 1982) near the southeast border of the Wilderness marks major Eocene intra-arc extension accompanying shift of activity from the Challis to Cascade arc system.

Vance, J. A., and Miller, R. B., 1981, The movement history of the Straight Creek fault in Washington State (abs.): Geological Association of Canada, Cordilleran Section, Program and Abstracts for 1981 Meeting, p. 39-41.

Willis, C. L., 1953, The Chiwaukum graben, a major structure of central Washington: American Journal of Science, v. 251, no. 11, p. 789-797.

Notes: Describes major, sedimentary-rock-filled graben extending northwestward from Wenatchee to just southeast of the Glacier Peak Wilderness. Bounding faults appear to extend northwestward into Wilderness area. See also Gresen's (1982) report on graben origin.

BEDROCK GEOLOGY AND PETROLOGY OF THE WILDERNESS AREA

(See figure 2 for location of geologic mapping)

Babcock, R. S., 1970, Geochemistry of the main-stage migmatitic gneisses in the Skagit Gneiss complex: Seattle, Washington University Ph.D. thesis, 147 p.

Notes: Provides description, petrology, and geochemistry of a major pre-Tertiary unit (Skagit Gneiss of Misch, 1966) north of the Glacier Peak Wilderness that is directly traceable southeastward into the Wilderness area in the vicinity of Stehekin River and the upper part of Lake Chelan.

Boak, J. L., 1977, Geology and petrology of the Mount Chaval area, north Cascades, Washington: Seattle, Washington University M.S. thesis, 87 p. (Fig. 2)

Brown, E. H., 1974, Comparison of the mineralogy and phase relations of blueschists from the North Cascades, Washington, and greenschists from Otago, New Zealand: Geological Society of America Bulletin, v. 85, p. 333-344.

Notes: North Cascades' blueschists described probably correlate with similar rocks west of the Straight Creek fault in and near westernmost part of Glacier Peak Wilderness.

Bryant, B. H., 1954, Metamorphism in the Snowking area, northern Cascades, Washington (abs.): Geological Society of America Bulletin, v. 65, no. 12, p. 1334.

_____1955, Petrology and reconnaissance geology of the Snowking area, northern Cascades, Washington: Seattle, Washington University Ph.D. thesis, 321 p. (Fig. 2)

Cater, F. W., Jr., 1960, Chilled contacts and volcanic phenomena associated with the Cloudy Pass batholith, Washington, in Short papers in the geological sciences: U.S. Geological Survey Professional Paper 400-B, p. B471-B473.

_____1969, The Cloudy Pass epizonal batholith and associated subvolcanic rocks: Geological Society of America Special Paper 116, 53 p.

_____1973, Stratigraphy and structure of the metamorphic rocks in the Lake Chelan-Glacier Peak area, western Washington (abs.): Geological Society of America Abstracts with Programs, v. 5, no. 1, p. 21.

_____1982, The intrusive rocks of the Holden and Lucerne quadrangles, Washington; the relation of depth zones, composition, textures, and emplacement of plutons: U.S. Geological Survey Professional Paper 1220, 108 p.

Cater, F. W., and Crowder, D. F., 1967, Geologic map of the Holden quadrangle, Snohomish and Chelan Counties, Washington (scale 1:62,500): U.S. Geological Survey Geologic Quadrangle Map GQ-646. (Fig. 2)

Cater, F. W., and Wright, T. L., 1967, Geologic map of the Lucerne quadrangle, Chelan County, Washington (scale 1:62,500): U.S. Geological Survey Geologic Quadrangle Map GQ-647. (Fig. 2)

Crowder, D. F., 1959, Granitization, migmatization, and fusion in the northern Entiat Mountains, Washington: Geological Society of America Bulletin, v. 70, no. 7, p. 827-877. (Fig. 2)

Crowder, D. F., Tabor, R. W., and Ford, A. B., 1966, Geologic map of the Glacier Peak quadrangle, Snohomish and Chelan Counties, Washington (scale 1:62,500): U.S. Geological Survey Geologic Quadrangle Map GQ-473. (Fig. 2)

Dotter, J. A., 1977, Prairie Mountain Lakes area, southeast Skagit County, Washington--structural geology, sedimentary petrography, and magnetics: Corvallis, Oregon State University M.S. thesis, 105 p. (Fig. 2)

Du Bois, R. L., 1954, Petrology and ore deposits of the Holden mine area, Chelan County, Washington: Seattle, Washington University Ph.D. thesis, 222 p. (Fig. 2)

_____1956, Petrology of the Holden mine area, Washington (abs.): Geological Society of America Bulletin, v. 67, no. 12, pt. 2, p. 1766.

Ford, A. B., 1957, The petrology of the Sulphur Mountain area, Glacier Peak quadrangle, Washington: Seattle, Washington University M.S. thesis, 103 p.

_____1959, Geology and petrology of the Glacier Peak quadrangle, northern Cascades, Washington: Seattle, Washington University Ph.D. thesis, 337 p. (Fig. 2)

_____1960, Metamorphism and granitic intrusion in the Glacier Peak quadrangle, northern Cascade Mountains of Washington (abs.): Geological Society of America Bulletin, v. 71, no. 12, pt. 1, p. 2059.

_____1983, Map of bedrock geologic data sites, Glacier Peak Wilderness study, Chelan, Skagit, and Snohomish Counties, Washington (scale 1:100,000): U.S. Geological Survey Open-File Report OF 83-454.

_____1983, Geologic studies along the Glacier Peak Wilderness and North Cascades National Park boundary (abs.): National Park Service, Pacific Northwest region, 1982 annual science report, p. 57-58.

Ford, A. B., Nelson, W. H., and Sonnevil, R. A., 1983, Glacier Peak Wilderness study, northern Cascades, Washington--geological map (abs.): Geological Society of America, Abstracts with Programs, v. 15, p. 400.

Ford, A. B., Nelson, W. H., Sonnevil, R. A., Loney, R. A., Huie, Carl, Haugerud, R. A., and Garwin, S. L., 1983, Geologic map of the Glacier Peak Wilderness and vicinity, Chelan, Skagit, and Snohomish Counties, Washington: U.S. Geological Survey Miscellaneous Field Investigations Map MF-1652-B.

Getsinger, J. S., 1978, A structural and petrologic study of the Chiwaukum Schist on Nason Ridge, northeast of Stevens Pass, North Cascades, Washington: Seattle, Washington University M.S. thesis.

Notes: Area lies south of area of figure 2. Discusses petrology of a major schist unit that extends northward into Wilderness area.

Grant, A. R., 1959, Geology and petrology of the Dome Peak area, northern Cascades, Washington: Seattle, Washington University M.S. thesis, 71 p.

_____1966, Bedrock geology of the Dome Peak area, Chelan, Skagit and Snohomish Counties, northern Cascades, Washington: Seattle, Washington University Ph.D. thesis, 270 p. (Fig. 2)

Heath, M. T., 1971, Bedrock geology of the Monte Cristo area, northern Cascades, Washington: Seattle, Washington University Ph.D. thesis, 164 p. (Fig. 2)

Hopson, C. A., Cater, F. W., and Crowder, D. W., 1970, Emplacement of plutons, Cascade Mountains, Washington: Geological Society of America Abstracts with Programs, v. 2, no. 2, p. 104.

Hopson, C. A., Crowder, D. F., Tabor, R. W., Cater, F. W., and Wise, W. S., 1966, Association of andesitic volcanoes in the Cascade Mountains with Late Tertiary epizonal plutons (abs.), in Abstracts for 1965: Geological Society of America Special Paper 87, p. 80.

Hopson, C. A., and Mattinson, J. M., 1971, Metamorphism and plutonism, Lake Chelan region, northern Cascades, Washington, in Metamorphism in the Canadian cordillera: Geological Association of Canada, Cordilleran Section, Vancouver, B.C., Programs and Abstracts, p. 13.

Libby, W. G., 1964, Petrography and structure of the crystalline rocks between Agnes Creek and the Methow Valley, Washington: Seattle, Washington University Ph.D. thesis, 133 p. (Fig. 2)

Milnes, P. T., 1976, Structural geology and metamorphic petrology of the Illabot Peaks area, Skagit County, Washington: Corvallis, Oregon State University M.S. thesis, 118 p. (Fig. 2)

Misch, Peter, 1959, Sodic amphiboles and metamorphic facies in Mount Shuksan belt, northern Cascades, Washington (abs.): Geological Society of America Bulletin 70, p. 1736-1737.

Notes: Discusses petrology of blueschists and greenschists of Misch's Shuksan Greenschist, a unit that extends southward to west margin of the Glacier Peak Wilderness, on the west side of the Straight Creek fault.

_____1968, Plagioclase compositions and non-anatectic origin of migmatitic gneisses in northern Cascade Mountains of Washington State: Contributions to Mineralogy and Petrology, v. 17, p. 1-70.

Notes: Detailed petrologic study of regionally developed migmatitic gneisses of the Skagit Gneiss of Misch (1966) in its type area: a unit that extends southward and makes up the eastern part of the Glacier Peak Wilderness. The unit also contains some orthogneiss members.

_____1969, Paracrystalline microboudinage of zoned grains and other criteria for synkinematic growth of metamorphic minerals: American Journal of Science, v. 267, p. 43-63.

Notes: Provides details on amphibole zoning history in the Shuksan Greenschist.

_____1977, Bedrock geology of the North Cascades, in Brown, E. H., and Ellis, R. C., eds., Geological excursions in the Pacific Northwest: Geological Society of America 1977 Annual Meeting, Seattle Washington (published by Department of Geology, Western Washington University, Bellingham, Washington), p. 1-62.

Notes: Geologic guide and road log along State Highway 20 from about 5 miles west of Marblemount to about 4 miles north of Washington Pass. Section along Skagit River gorge shows exposure of units (Darrington Phyllite, Shuksan Greenschist, Marblemount Meta-Quartz Diorite, Cascade River Schist, and Skagit Gneiss, as defined by Misch) correlative with units in and near the Glacier Peak Wilderness. Guide describes rock units and their structural setting and contains a geologic sketch map of the upper Skagit region, including northernmost part of Wilderness area.

_____1981, Phosphorous precipitation front coincident with Al infiltration front in metasomatic margins of metaperidotite pods in lower and upper amphibolite-facies Skagit Metamorphic Suite, North Cascades, Washington (abs.): Geological Society of America Abstracts with Programs, v. 13, p. 47.

Notes: Metaperidotite pods of possibly similar origin are scattered widely in a mainly central belt of the Glacier Peak Wilderness.

Misch, Peter, and Onyeagocha, A. C., 1976, Symplectite breakdown of Ca-rich almandines in upper amphibolite-facies Skagit Gneiss, North Cascades, Washington: Contributions to Mineralogy and Petrology, v. 54, p. 189-224.

Misch, Peter, and Rice, J. M., 1975, Miscibility of tremolite and hornblende in progressive Skagit Metamorphic Suite, North Cascades, Washington: Journal of Petrology, v. 26, no. 1, p. 1-21.

Notes: Petrologic and analytical study by electron microprobe of amphiboles from units (Cascade River Schist, Skagit Gneiss) near and north of Cascade River that extend southeastward into the Glacier Peak Wilderness.

Morrison, M. E., 1954, Petrology of the Phelps Ridge-Red Mountain area, Chelan County, Washington: Seattle, Washington University M.S. thesis, 95 p. (Fig. 2)

Plummer, C. C., 1980, Dynamothermal contact metamorphism superposed on regional metamorphism in the pelitic rocks of the Chiwaukum Mountains area, Washington Cascades; Summary: Geological Society of America Bulletin, pt. I, v. 91, p. 386-388 (Full report in microfische in Geological Society of America Bulletin, pt. II, v. 91, p. 1627-1668).

Pytlak, S. R., 1970, Geology of the Blanca Lake area, Snohomish County, Washington: Seattle, Washington University M.S. thesis, 45 p.

Rosenberg, E. A., 1961, Geology and petrology of the northern Wenatchee Ridge area, northern Cascades, Washington: Seattle, Washington University M.S. thesis, 109 p. (Fig. 2)

Tabor, R. W., 1958, The structure and petrology of the Magic-Formidable region in the northern Cascades of Washington: Seattle, Washington University M.S. thesis, 81 p.

_____1960, Diaphthoritic gneiss in the northern Cascades, Washington, and its structural significance (abs.): Geological Society of America Bulletin, v. 71, p. 2079.

_____1961, The crystalline geology of the area south of Cascade Pass, northern Cascade Mountains, Washington: Seattle, Washington University Ph.D. thesis, 205 p. (Fig. 2)

_____1963, Large quartz diorite dike and associated explosion breccia, northern Cascade Mountains, Washington: Geological Society of America Bulletin, v. 74, no. 9, p. 1203-1208.

Tabor, R. W., and Crowder, D. F., 1969, On batholiths and volcanoes--intrusion and eruption of late Cenozoic magmas in the Glacier Peak area, North Cascades, Washington: U.S. Geological Survey Professional Paper 604, 67 p.

Tabor, R. W., Frizzell, V. A., Jr., Booth, D. B., Whetten, J. T., Waitt, R. B., Jr., and Zartman, R. E., 1982, Preliminary geologic map of the Skykomish River 1:100,000 quadrangle, Washington: U.S. Geological Survey Open-File Map OF 82-747, 31 p. (Fig. 2)

Tabor, R. W., Frizzell, V. A., Jr., Whetten, J. T., Swanson, D. A., Byerly, G. R., Booth, D. B., Hetherington, M. J., and Waitt, R. B., Jr., 1980, Preliminary geologic map of the Chelan 1:100,000 quadrangle, Washington: U.S. Geological Survey Open-File Map 80-841, 46 p. (Fig. 2)

Tabor, R. W., Frizzell, V. A., Jr., Yeats, R. S., and Whetten, J. T., 1982, Geologic map of the Eagle Rock and Glacier Peak Roadless Areas, Snohomish and King Counties (scale 1:100,000): U.S. Geological Survey Miscellaneous Field Investigations Map MF-1380-A. (Fig. 2)

Vance, J. A., 1957, The geology of the Sauk River area in the northern Cascades of Washington: Seattle, Washington University Ph.D. thesis, 312 p. (Fig. 2)

_____1982, Cenozoic stratigraphy and tectonics of the Washington Cascades (abs.): Geological Society of America Abstracts with Programs, v. 14, no. 4, p. 241.

Notes: Mentions that Straight Creek fault near west border of Glacier Peak Wilderness is a major dextral strike-slip fault largely predating Eocene age, with late dip-slip movements affecting rocks as young as mid-Eocene.

Vance, J. A., Dungan, M. A., Blanchard, D. P., and Rhodes, J. M., 1980, Tectonic setting and trace element geochemistry of Mesozoic ophiolitic rocks in western Washington: American Journal of Science, v. 180-A, p. 359-388.

Notes: In part, describes Middle to Late Jurassic ophiolite (Stillaguamish) and associated Late Jurassic units (Darrington Phyllite and Shuksan Greenschist members of the Easton Schist) lying west of the Straight Creek fault in and near westernmost part of the Glacier Peak Wilderness.

Van Diver, B. B., 1964, Petrology of the metamorphic rocks, Wenatchee Ridge area, central northern Cascades, Washington: Seattle, Washington University Ph.D. thesis, 140 p. (Fig. 2)

_____1965, Synmetamorphic faulting in White River orthogneiss of Wenatchee Ridge area, central North Cascades, Washington: Geological Society of America Special Paper 82, p. 285.

_____1967, Contemporaneous faulting-metamorphism in Wenatchee Ridge area, northern Cascades, Washington: American Journal of Science, v. 265, p. 132-150.

Waters, A. C., 1932, A petrologic and structural study of the Swakane gneiss, Entiat Mountains, Washington: Journal of Geology, v. 40, no. 6, p. 604-633.

Yardley, B. W. D., 1978, Genesis of the Skagit Gneiss migmatites, Washington, and the distinction between possible mechanisms if migmatitization: Geological Society of America Bulletin 89, p. 941-951.

Notes: Petrologic study, in an area north of the Skagit Valley, of a major rock unit that extends southeastward into eastern part of the Glacier Peak Wilderness.

GEOCHRONOLOGY AND ISOTOPE STUDIES

Armstrong, R. L., 1980, Geochronometry of the Shuksan Metamorphic Suite, North Cascades, Washington (abs.): Geological Society of America, Abstracts with Programs, v. 12, no. 3, p. 94.

Notes: New K-Ar dates of 219 ± 9 m.y. and 221 ± 9 m.y. confirm earlier dating that some blueschists are pre-Jurassic. Others show younger ages suggesting Late Jurassic-Early Cretaceous blueschist metamorphism. Concludes that the North Cascades are a mid-Mesozoic accretionary wedge of tectonic terrane fragments, including Triassic and Jurassic-Cretaceous blueschists.

Baadsgaard, H., Folinsbee, R. E. and Lipson, J. I., 1961, Potassium-argon dates of biotites from Cordilleran granites: Geological Society of America Bulletin, v. 27, no. 5, p. 689-701.

Church, S. E., 1970, Lead and strontium isotope geochemistry of the Cascade Mountains: Santa Barbara, California University Ph.D. thesis, 124 p.

_____1976, The Cascade Mountains revisited: a re-evaluation in light of new lead isotopic data: Earth and Planetary Science Letters, v. 29, p. 175-178.

Notes: Restudy of Cascade volcanic rocks of Church and Tilton (1973), including samples from Glacier Peak. From lead isotope data, the author proposes a model of crustal contamination and (or) assimilation at the crust-mantle interface in the origin of magmas of Cascade volcanoes.

Church, S. E., and Tilton, G. R., 1973, Lead and strontium isotopic studies in the Cascade Mountains; bearing on andesite genesis: Geological Society of America Bulletin, v. 84, no. 2, p. 431-454.

Notes: Contains lead and strontium isotopic and other chemical data from Cascade volcanoes, including Glacier Peak, for which isotopic composition of strontium is found to be remarkably constant ($^{87}Sr/^{86}Sr$ averages 0.7037). Data are best explained by multistage partial melting of mantle material rather than by any major results of crustal processes such as melting of graywacke or contamination.

Davis, G. L., Tilton, G. R., Aldrich, L. T., Hart, S. R., and Steiger, R. H., 1966, Isotopic composition of lead and strontium in crystalline rocks from the Northern Cascade Range, United States, in Geochronology and isotope geochemistry in Geophysical Laboratory Report: Carnegie Institute Washington Year Book 64, 1964-1965, p. 171-177.

Engels, J. C., Tabor, R. W., Miller, F. K., and Obradovich, J. D., 1976, Summary of K-Ar, Rb-Sr, U-Pb, Pb, and fission-track ages of rocks from Washington State prior to 1975 (exclusive of Columbia Plateau basalts): U.S. Geological Survey Miscellaneous Field Studies Map MF-710, 2 sheets, scale 1:1,000,000.

Hedge, C. E., Hildreth, R. A., and Henderson, W. T., 1970, Strontium isotopes in some Cenozoic lavas in Oregon and Washington: Earth and Planetary Science Letters, v. 8, no. 6, p. 434-438.

Notes: From $^{87}Sr/^{86}Sr$ analyses of three Glacier Peak dacite samples (average, 0.7037) suggests derivation of lavas from upper mantle. Percent of incorporated sedimentary material, if any, must have been minor (less than 20 percent) in order to satisfy isotopic data.

Mattinson, J. M., 1970a, Uranium-lead geochronology of the northern Cascade Mountains, Washington: Santa Barbara, California University Ph.D. thesis, 80 p.

Notes: Based on radiometric age determinations on zircons, gneisses and schists of supracrustal origin comprise at least two age groups. In the area of the Glacier Peak Wilderness, the older includes Swakane Gneiss and possibly Skagit Gneiss that may have been deposited 2,000 m.y. ago or, alternatively, may be as young as early Paleozoic but derived from a 2,000-m.y.-old source terrane. The younger group are gneissic rocks of the Holden area and the Cascade River Schist that were deposited in Late Paleozoic or early Mesozoic time. Other Glacier Peak Wilderness rock units dated include Marblemount Meta-Quartz Diorite and Dumbell Mountain plutons (220 m.y.) and Eldorado Orthogneiss (91 m.y.). Ages of pegmatites, synkinematic intrusions, and metamorphic minerals indicate major metamorphic events of about 415 m.y. and 60-90 m.y. age.

_____1970b, Uranium-lead geochronology of the northern Cascade Mountains, Washington (abs.): Geological Society of America Abstracts with Programs, v. 2, no. 2, p. 116.

_____1972, Ages of zircons from the northern Cascade Mountains, Washington: Geological Society of America Bulletin, v. 83, p. 3769-3784.

Meijer, Arend, 1971, Isotopic composition of strontium in epizonal granodiorite plutons, Cascade Mountains (abs.): Geological Society of America, Abstracts with Programs, v. 3, no. 7, p. 645.

Notes: Reports that $^{87}Sr/^{86}Sr$ ratios for Cloudy Pass and Sitkum Creek plutons are very uniform (0.7049-0.7052) and higher than Glacier Peak lava ratios (0.7032-0.7037), indicating possible magma contamination prior to intrusion. Data are compatible with derivation of magma and andesitic lava largely from upper mantle or lower crust sources.

Misch, Peter, 1964, Age determinations on crystalline rocks in northern Cascade Mountains, Washington, in Kulp, J. L., and others, Investigations in isotope geochemistry: U.S. Atomic Energy Commission Publication NYO-7243, App. D, p. 1-15.

Sans, J. R., 1979, An oxygen isotope study of the Cloudy Pass batholith, Washington (abs.): Geological Society of America, Abstracts with Programs, v. 11, no. 7, p. 510.

Tabor, R. W., Frizzell, V. A., Jr., Whetten, J. T., Swanson, D. A., Byerly, G. R., Booth, D. B., Hetherington, M. J., and Waitt, R. B., Jr., 1980, Preliminary geologic map of the Chelan 1:100,000 quadrangle, Washington: U.S. Geological Survey Open-file Map OF-80-841, 46 p.

Notes: Contains summary of all radiometric ages of units in quadrangle, including those in parts of Glacier Peak Wilderness (Duncan Hill and Tenpeak plutons and Swakane Biotite Gneiss, and a correlative--the Entiat pluton--of the Seven-Fingered Jack plutons).

Tilton, G. R., and Hopson, C. A., 1970, Isotopic composition of lead in plutonic and volcanic rocks from the northern Cascade Mountains (abs.): Geological Society of America, Abstracts with Programs, v. 2, no. 7, p. 707.

Notes: Isotopic composition of lead is used to test possible genetic relationship between andesitic or dacitic lavas, including of Glacier Peak, and neighboring granodioritic plutons. Preliminary data for Glacier Peak (and Mt. St. Helens) show substantial differences in lead isotopic compositions between volcanic and plutonic rocks, suggesting either contamination of the lead or different sources for the two kinds of rocks.

GEOPHYSICAL STUDIES

Aiken, C. L. V., 1970, Gravimetric profiles across northern Cascades employing minimum assumptions as to subsurface density distribution: Seattle, Washington University M.S. thesis, 134 p.

Danes, Z. F., and Phillips, W. M., 1983, Complete Bouguer gravity anomaly map of the Cascade Mountains, Washington (scale 1:250,000): State of Washington Division of Geology and Earth Resources Geophysical Map GM-27.

Dotter, J. A., 1978, Prairie Mountain Lakes area, southeast Skagit County, Washington--structural geology, sedimentary petrography, and magnetics: Corvallis, Oregon State University M.S. thesis, 105 p.

Flanigan, V. J., Ford, A. B., and Sherrard, Mark, 198_, Glacier Peak Wilderness study, northern Cascades, Washington--Geologic interpretation of aeromagnetic map: U.S. Geological Survey Open-File Report OF- . (In press)

Flanigan, V. J., and Sherrard, Mark, 1983, Glacier Peak Wilderness study, northern Cascade Range, Washington--aeromagnetic and Bouguer gravity data (abs.): Geological Society of America, Abstracts with Programs, v. 15, p. 400-401.

U.S. Geological Survey, 1979, Aeromagnetic map of Cascade Pass area, Washington (scale 1:62,500): U.S. Geological Survey Open-File Report OF 79-1645.

_____1982, Aeromagnetic map of the Dome Peak area, Washington: U.S. Geological Survey Open-File Report 82-548, 1 sheet, scale 1:62,500.

_____1982, Aeromagnetic map of Glacier Peak, Washington: U.S. Geological Survey Open-File Report 82-541, 1 sheet, scale 1:62,500.

MINERAL DEPOSITS AND RESOURCE STUDIES

Adams, N. B., 1976, The Holden Mine: from discovery to production, 1896-1938: Seattle, Washington University Ph.D. thesis, 236 p.

Notes: The history of the Holden Mine begins with James Henry Holden's 1893 search of the Lake Chelan area for minerals and his 1896 discovery of the deposit in the Railroad Creek valley and subsequent staking of claims. The report covers the 42-year period of promotion and development until shipment of the first concentrate in 1938, precursory to the Holden Mine becoming the largest non-ferrous mine in Washington State, with production of 212,000,000 lbs copper, 40,000,000 lbs zinc, 2,000,000 oz silver, and 600,000 oz gold extracted from 10,000,000 tons of ore during 19 years (1938-57) of mining. Gross metal value was $66 million.

Anderson, B. L., 1938, Petrography and ore genesis of the Holden ore deposit: Seattle, Washington University B.S. thesis, 39 p.

Armstrong, R. L., Harakal, J. E., and Hollister, V. F., 1976, Age determination of late Cenozoic porphyry copper deposits of the North American Cordillera: Institution of Mining and Metallurgy, Section B, Transactions, v. 85, p. B239-B244.

Notes: Dates of 6.25, 9.9, 16.2, 17.3, and 24.0 m.y. are given for deposits in the Cascade volcanic arc, western Washington, not including any from Glacier Peak Wilderness. Authors suggest that porphyry-type mineralization is constantly associated with volcanic-arc igneous activity and may be taking place now in the vicinity of magma chambers of active Cascade volcanoes.

Barquist, W. S., 1927, Tests on ore from the St. Francis vein, Phelps Ridge, Chelan County, Washington: Seattle, Washington University B.S. thesis, 52 p.

Boentje, J. D., Jr., 1939, The mining method at the Holden mine: Seattle, Washington University B.S. thesis, 55 p.

Broughton, W. A., 1942, Inventory of mineral properties in Snohomish County, Washington: Washington Division of Geology Report of Investigations 6, 72 p.

Carithers, Ward, 1940, Pumice and pumicite occurrences of Washington: Washington Division of Mines and Geology Report of Investigations 15, 78 p.

Notes: Describes, among others, pumice and pumicite deposits in Chiwawa and Entiat Valleys that are related to Glacier Peak eruptions. Some have been worked for commercial use as light-weight aggregate in concrete blocks.

Church, S. E., Ford, A. B., Flanigan, V. J., and Stotelmeyer, R. B., 198_, Mineral resource potential map of the Glacier Peak Wilderness and adjacent areas, Chelan, Skagit, and Snohomish Counties, Washington (scale 1:100,000): U.S. Geological Survey Miscellaneous Field Studies Map MF-1652-A. (In press)

Church, S. E., Mosier, E. L., and Frisken, J. G., 1983, Contour maps of analytical results for stream sediments and panned concentrates from stream sediments, and plots of the mineralogy of the nonmagnetic, heavy-mineral concentrates from stream sediments from the Glacier Peak Wilderness study area, Washington: U.S. Geological Survey Open-File Report OF 83-366, 37 p.

Church, S. E., Mosier, E. L., Frisken, J. G., Arbogast, B. F., McDougal, C. M., and Evans, J. G., 1982, Analytical results for stream sediments and panned concentrates from stream sediments collected from the Glacier Peak Wilderness and adjacent areas, Washington: U.S. Geological Survey Open-File Report OF-82-780, 227 p.

Church, S. E., Mosier, E. L., Motooka, J. M., and Frisken, J. G., 1983, Geochemical studies of Glacier Peak Wilderness study area, northern Cascades, Washington (abs.): Geological Society of America, Abstracts with Programs, v. 15, p. 401.

Church, S. E., Motooka, J. M., Werschky, R. S., Bigelow, R. C., and Van Trump, Jr., George, 1983, Contour maps, statistical summaries, and analytical data from stream-sediment samples collected from the Glacier Peak (Wilderness) area and analyzed using an aqua regia leach/inductively coupled plasma method: U.S. Geological Survey Open-File Report OF 83-343, 116 p.

Church, S. E., and Stotelmeyer, R. B., 198_, Glacier Peak Wilderness study area, Washington, in Marsh, S. P., Kropschot, S. J., and Dickenson, R. G., eds., Wilderness mineral potential--appraisal of mineral resource potential in U.S. Forest Service lands studied 1964-1984: U.S. Geological Survey Professional Paper 1300. (In press)

Coats, R. R., 1931, The nature of the ore deposit of the Chelan Copper Mining Company at Chelop (Holden), Chelan County, Washington: Seattle, Washington University B.S. thesis, 30 p.

Crafts, E. C. (Chairman, North Cascades Study Team), 1965, The north Cascades, a report to the Secretary of the Interior and the Secretary of Agriculture: U.S. Departments of Interior and Agriculture, 190 p.

Notes: General summary of natural resources including timber, recreation, fish and wildlife, minerals, water and power, and range use, with recommendations for Wilderness and National Park designations.

Crook, A. R., 1904, Molybdenite at Crown Point, Washington: Geological Society of America Bulletin, v. 15, p. 283-288.

Curzon, J. J., 1941, Mining methods used at the Holden mine: Mining Congress Journal, v. 27, no. 3, p. 10-17.

Danner, W. R., 1966, Limestone resources of western Washington: Washington Division of Mines and Geology Bulletin 52, 474 p.

Notes: Describes deposits of limestone (marble) on Circle Peak, the ridge between Circle Peak and Meadow Mountain, and the northern hillslope below Lime Mountain. Chemical analyses are provided for the Circle Peak and Lime Mountain deposits. No development on any, but 14 claims staked on the Lime Mountain deposit.

Du Bois, R. L., 1954, Petrology and ore deposits of the Holden mine area, Chelan County, Washington: Seattle, Washington University Ph.D. thesis, 222 p.
Notes: Provides detailed account of the geology, petrology, and structure of the area of the Holden mine. Describes mineralogy of the ore and gangue material, zoning of the deposit, wall-rock alteration, structural control of ore deposition, and gives a genetic interpretation that relates metallization to high-rank regional synkinematic metamorphism.

_____1956, Petrology of the Holden mine area, Washington (abs.): Geological Society of America Bulletin, v. 67, no. 2, p. 1766.

Duncan, W. P., 1939, The mineralogy of the Holden ore body: Seattle, Washington University B.S. thesis, 48 p.

Grant, A. R., 1969, Chemical and physical controls for ore deposits in the Cascade Range of Washington: Washington Division of Mines and Geology Bulletin 58, 107 p.

Notes: Outlines general geology and structure of the northern Cascades and describes granitic intrusive activity, alteration, and structural features associated with mainly copper mineralization. Many of the important mining districts seem to lie on transverse structural belts, or "lineaments," two of which in the vicinity of the Glacier Peak Wilderness are the "Buckindy belt" (Darrington-Mt. Buckindy-Cascade Pass-Thunder Creek mining district) and the "Glacier Peak belt" (Sultan Basin-Monte Cristo-Miners Ridge-Holden-Meadow Creek mining district on east side of Lake Chelan). Describes the geology and ore deposits of Miners Ridge and Mt. Buckindy areas.

_____1982, Summary of economic geology data for the Glacier Peak Wilderness, Chelan, Snohomish, and Skagit Counties, Washington: U.S. Geological Survey Open-File Report OF 82-408, 37 p.

Hodges, L. K., 1897, Mining in the Pacific Northwest: Seattle Post-Intelligencer, library no. 622.H, p. 5-83.

Notes: A good early history of mining in the vicinity of Glacier Peak Wilderness.

Hollister, V. F., 1979, Porphyry copper-type deposits of the Cascade volcanic arc, Washington: Minerals, Science, and Engineering, v. 11, no. 1, p. 22-35.

Notes: Discusses Glacier Peak (Miners Ridge) porphyry copper deposit and its alteration zones, and points out that the best grade of hypogene ore occurs near the boundary of the potassic and phyllic zones. Points out that "That portion of the Cascade volcanic arc in which the porphyry copper deposits are found is distinct from many other arcs because it is not underlain by a Benioff zone nor is it fronted by a recognizable trench."

Horton, F. W., 1916, Molybdenum; its ores and their concentrations: U.S. Bureau of Mines Bulletin 111, p. 79-83.

Notes: Describes molybdenite-bearing deposit at Crown Point near the head of Railroad Creek. Unusually well-formed crystals of the mineral, up to 5 in. in diameter, are scattered irregularly in a white quartz vein 3 in. to 3 ft thick. Aurelia Crown Co. reports that molybdenite masses of 5-11 lb weight were mined. Development work consisted of two short tunnels, 200 and 80 ft long. Production of 10-12 tons of high-grade ore occurred in 1901 and 1902.

Huntting, M. T., 1955, Gold in Washington: Washington Division of Mines and Geology Bulletin 42, 158 p.

Notes: Lists and briefly describes lode and placer gold prospects and mines in vicinity of Glacier Peak Wilderness. At Holden, mill feed averaged 0.09 oz gold and 0.344 oz silver in 1940, and 0.44 oz gold and 0.213 oz silver in 1951. 1951 metals production included 24,205 oz gold and 117,437 oz silver (along with 4,015 tons copper and 1,958 tons zinc) from 550,530 tons of ore.

_____1956, Metallic minerals, Part 2 of Inventory of Washington minerals: Washington Division of Mines and Geology Bulletin 37, v. 1, 428 p. (with maps in v. 2).

Huttl, J. B., 1938, Howe Sound's Holden mine nears production: Engineering and Mining Journal, v. 139, no. 1, p. 32-35.

Mariner, R. H., Presser, T. S., and Evans, W. C., 1982, Chemical and isotopic composition of water from thermal and mineral springs of Washington: U.S. Geological Survey Open-File Report 82-98, 18 p.

Notes: Contains chemical data for the three thermal springs in the Glacier Peak Wilderness and vicinity: Gamma, Kennedy, and Sulphur Hot Springs. Of interest for evaluating possible geothermal resources, gives calculated temperatures of aquifers based on a variety of chemical geothermometers: Gamma, 178-216°C (352-421°F); Kennedy, 145-189°C (293-372°F); and Sulphur, 110-117°C (230-243°F). None of the springs are associated with siliceous sinter, a general indicator of high subsurface temperature.

May, R. F., 1947, Recovery of gold and sphalerite from mill tailings at Holden: Seattle, Washington University B.S. thesis, 56 p.

McPhee, John, 1971, Encounters with the Archdruid: New York, Farrar, Strauss and Giroux, 245 p.

Notes: Discussions of environmental issues concerning three wilderness areas. Chapter 1 deals with possible exploitation of copper deposit on Miners Ridge, Glacier Peak Wilderness.

McWilliams, J. R., 1958, Mining methods and costs at the Holden mine, Chelan Division, Howe Sound Co., Chelan County, Washington: U.S. Bureau of Mines Information Circular 7870, 44 p.

Moen, W. S., 1976, Silver occurrences of Washington: Washington Division of Geology and Earth Resources Bulletin 69, 188 p.

Notes: Silver prospects and deposits in or near Glacier Peak Wilderness are chiefly Holden (Chelan district), Royal (Chiwawa district), and, of lesser importance, 10 properties near Cascade River and Cascade Pass (Cascade-Thunder Creek district). Holden was one of two leading producers of gold and silver in Washington State in the 1950's. From 1938 to 1958 Holden produced a total of 2,000,000 oz silver and 600,000 oz gold, along with 106,000 tons copper and 20,000 tons zinc. Combined production was $66.5 million, making it one of Washington's richest metal deposits. Holden closed in 1961. The Royal copper mine (Red Mountain) opened in 1935 and produced 7,694 oz silver in 1936 and 4,282 oz in 1937.

_____ 1982, The mineral industry of Washington--Highlights of its development, 1853-1980: Washington Division of Geology and Earth Resources Information Circular 74, 26 p.

Notes: From 1938 through 1957 the Holden mine produced a total of 10.6 million tons of copper-gold-silver-zinc ore valued at $65.5 million.

Morrison, M. E., 1954, The petrology of the Phelps Ridge-Red Mountain area, Chelan County, Washington: University of Washington M.S. thesis, 95 p.

Notes: Describes geologic setting of mines and prospects in the vicinity of Trinity. Chief development work by the Royal Development Company was the driving of a 10,957 ft adit at the Red Mountain Mine to intersect an ore body (St. Francis) discovered earlier. The chief ore mineral is chalcopyrite. Mill production of 10,000 tons of ore in 1936 and 5,825 tons in 1937 is reported. The mine was closed March 1, 1937. In the ore zone of the Trinity breccia, chalcopyrite is associated with pyrrhotite, sphalerite, pyrite, arsenopyrite, galena, scheelite, and very small amounts of molybdenite.

Neff, J. L., and Magnuson, R. L., 1974, Mining laws of the State of Washington: Washington Division of Geology and Earth Resources Bulletin 67, 109 p.

Notes: Provides description and discussion of regulations and laws related to prospecting, claim staking, patenting, leasing, rights-of-way, environmental safeguards, and other matters involved in metallic and nonmetallic resource development on private, State, and Federal lands, including wilderness lands. The 1964 Wilderness Act provides that wilderness areas designated by Congress in the act, such as the Glacier Peak Wilderness, or by later legislation, shall be open to entry under the location laws and the mineral leasing laws until December 31, 1983, but not thereafter.

Northwest Mining Journal, 1909, Mineral resources of Washington: Northwest Mining Journal Co., Seattle, Washington, special A.Y.P.E. sic number.

Popoff, C. C., 1949, Investigation of the Whitechuck travertine deposit near Darrington, Snohomish County, Washington: U.S. Bureau of Mines Report of Investigations 4565, 4 p.

Purdy, C. P., Jr., 1954, Molybdenum occurrences of Washington: Washington Division of Mines and Geology Report of Investigations 18, 118 p.

Notes: Discusses molybdenite localities at Crown Point, near the head of Railroad Creek, and the Glacier Peak copper property on Miners Ridge. Production at Crown Point mine was minor, including shipment in 1903 of a "large crystal or cluster of molybdenite crystals" weighing 300 pounds. The mine produced some of the world's finest molybdenite crystals, but it is considered unlikely that many more will be found or that the mine will be a commercial source of molybdenum. For the Miners Ridge deposit it is estimated that there are several million tons of ore containing about 1 percent copper and 0.1 percent molybdenum, with average values of 0.0022 oz per ton gold and 0.283 oz per ton silver.
Added note: The Miners Ridge data precede the extensive explorations in the 1950's and 1960's by Bear Creek Mining Company. See reports by Grant (1982) and Stotelmeyer and others (1981).

Richarz, Stephen, 1933, Peculiar gneisses and ore formations in the eastern Cascades, Washington: Journal of Geology, v. 41, p. 757-769.

Notes: Description of geology and ore deposit at Trinity.

Robyn, T. L., Henage, L. F., and Hollister, V. F., 1981, Possible subduction associated porphyry ore deposits, Pacific Northwest, in Silberman, M. L., Field, C. W., and Berry, A. L., eds., Proceedings of the symposium on mineral deposits of the Pacific Northwest, Geological Society of America meeting, Corvallis, Oregon, March 20-21, 1980: U.S. Geological Survey Open-File Report 81-355, p. 153-165.

Notes: Metals of porphyry deposits from calc-alkaline magmas in the northern Cascades were not derived from subducted oceanic crust, but were scavenged from upper crust. Deposits younger than 22 m.y. are of non-subduction origin. Shows location of Glacier Peak and Trinity deposits on Bouguer gravity map of U.S. that suggests a Basin- and Range-type structural setting.

Soderberg, R. L., 1948, Mining methods at the Holden mine, Howe Sound Company, Chelan Division, Holden, Washington: U.S. Bureau of Mines Information Circular 7448, 27 p.

Notes: Provides interesting early account of discovery and development of the Holden ore deposit. Gives detailed account, with numerous diagrams, of methods for sampling, drilling, blasting, ventilating, ore hauling, and other operations.

Spurr, J. E., 1901, The ore deposits of Monte Cristo, Washington: U.S. Geological Survey 22d Annual Report, pt. 2, p. 777-865.

Stotelmeyer, R. B., 1983, Glacier Peak Wilderness study, northern Cascades, Washington--mines and prospects map (abs.): Geological Society of America, Abstracts with Programs, v. 15, p. 398.

Stotelmeyer, R. B., Johnson, F. L., McHugh, E. L., Federspiel, F. E., Denton, D. K., Jr., and Stebbins, S. A., 1982, Mineral investigation of the Glacier Peak Wilderness and adjacent areas, Chelan, Skagit, and Snohomish Counties, Washington: U.S. Bureau of Mines Open-File Report MLA 89-82, 32 p.

Thorne, R. L., 1931, Tests on the Chelan Copper Mining Company's ore: Seattle, Washington University B.S. thesis, 64 p.

Valentine, G. M., 1960, Nonmetallic minerals, Part 1, 2nd ed. (revised by Huntting, M. T.), of Inventory of Washington minerals: Washington Division of Mines and Geology Bulletin 37, 175 p. (2 vol.).

Notes: Brief descriptions of occurrences (in vol. 1, text) with maps showing location (vol. 2) of nonmetallic minerals of the state, including those of kyanite, asbestiform materials, beryl, garnet, quartz crystal, graphite, limestone, mica, pumice and pumicite, sand and gravel, and talc and soapstone in and near the Glacier Peak Wilderness.

Vonheeder, E. R., 1982, Minerals and energy exploration activities in Washington: Washington Division of Geology and Earth Resources Geologic Newsletter, v. 10, no. 1, p. 1-8.

Watson, D. W., 1957, Ore localization at the Holden mine, Chelan County, Washington: Pullman, Washington State University M.S. thesis, 43 p.

Willms, E. P., 1941, Stoping with diamond drill blast-holes at the Holden mine: Seattle, Washington University B.S. thesis, 99 p.

Young, G. H., 1941, The Diamond mine: Seattle, Washington University B.S. thesis, 72 p.

Notes: Describes narrow veins of mostly galena and pyrite with minor chalcopyrite in a prospect about 4 miles northwest of Cascade Pass. Most veins show values in lead, zinc, and silver and some also in gold.

Youngberg, E. A., and Wilson, T. H., 1952, The geology of the Holden mine: Economic Geology, v. 47, p. 1-12.