The Ore Bin

Volume 38, No. 2
February 1976

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland, Oregon - 97201
Telephone: [503] - 229-5580

FIELD OFFICES

2033 First Street
Baker 97814

521 N. E. "E" Street
Grants Pass 97526

x x x x x x x x x x x x x x x x x x x x x

Subscription Rate
1 year - $3.00; 3 years - $8.00
Available back issues - $.25 at counter; $.35 mailed

Second class postage paid at Portland, Oregon

State of Oregon
Department of Geology
and Mineral Industries
1069 State Office Bldg.
Portland Oregon 97201

The ORE BIN
Volume 38, No. 2
February 1976

THE SIGNIFICANCE OF INCREASED FUMAROLIC ACTIVITY AT MOUNT BAKER, WASHINGTON

C. L. Rosenfeld* and H. G. Schlicker**

Introduction

A dramatic increase in thermal activity in Sherman Crater on Mount Baker, Washington, has spurred geoscientists into keeping watch for significant changes that might prophesy a large-scale eruption or catastrophic mudflow.

Mount Baker is the northernmost in a chain of high volcanic peaks that forms the crest of the Cascade Range and extends as far south as Mount Lassen in northern California. The chain is part of the circum-Pacific belt of active, or recently active, volcanoes sometimes referred to as the "Ring of Fire."

The recency of volcanic activity in the Cascade Range indicates that its volcanoes are not dead. Mount Lassen, for example, erupted as late as 1915, and fumaroles on other peaks may mean the volcanoes are sleeping with one eye open. The problem now for geoscientists is to decide whether the volcanoes are cooling off from the last major eruptions or warming up for the next.

Volcanic History of the Cascade Range

The Cascade Range is largely the product of volcanism, which began during the Eocene Epoch, about 40 million years ago, and continued through the Pleistocene with the eruption of the large stratovolcanoes that form the glaciated, snow-capped peaks of the present-day High Cascades.

The "basement" rocks beneath the volcanic peaks were emplaced from Eocene through Pliocene time. A considerable thickness of lava flows, pyroclastic rocks, volcanic sediment, and ash flows were deposited during the Eocene and Oligocene Epochs. In early Miocene time, intermittent intrusions of granodiorite batholiths and stocks penetrated the older rocks. Following a period of regional uplift and erosion, flood basalts of the

*Department of Geography, Oregon State University, Corvallis
**Oregon Department of Geology and Mineral Industries

Columbia River Group blanketed much of the land. Beginning in Pliocene time, low, shield-shaped volcanoes formed the broad base for the large complex volcanoes that erupted in Pleistocene time. Intensive glaciation during the Pleistocene etched deeply into the flanks of these volcanoes, creating the familiar shapes of the peaks we see today.

There is abundant evidence that volcanism has continued in the Cascade Range since Pleistocene time. Mount Lassen was active as late as 1915. Mount Hood, St. Helens, Rainier, and Baker probably erupted within the past century, and other Cascade peaks were active somewhat earlier.

Geologic mapping, carbon-14 dating, dendrochronology, and numerous confirmed sightings collectively substantiate recent volcanism averaging about one major eruption per century for the past 2,500 years.

Mount Hood

Mount Hood, a stratovolcano, was once 500 to 1,000 feet higher than at present but was reduced in size and height by glaciation. Two relatively recent volcanic eruptions have occurred on Mount Hood. One near Cloud Cap Inn on the north face of the mountain erupted ash about 1800, according to Lawrence (1948), who estimated the age by ring count of trees growing from an ash layer which, in turn, rests on a moraine which became free of ice at about the year 1740 (as determined by dendrochronology). Another vent, on the south side of the mountain, erupted pasty lava about 2,000 years ago. The remnant volcanic plug from this vent is known as Crater Rock. A large uniformly sloping debris fan extends from Crater Rock to the vicinity of Timberline Lodge and was probably derived from material produced from this vent. Several fumaroles still emit water vapor and noxious gases at Crater Rock. The steam from these vents can be seen during clear, crisp, cold weather (Figure 1). On December 12, 1974, a crustal seismic shock of magnitude 4.1 was recorded. The epicenter was in the vicinity of Government Camp. Whether this shock was of volcanic rather than tectonic origin has not been determined (Richard Couch, OSU Oceanography, personal communication). Although the most recent significant volcanic activity was the eruption 2,000 years ago, the continued fumarolic action and the possible relationship of seismic activity to magma movement within the crust would suggest that Mount Hood could erupt at any time.

Mount St. Helens

Mount St. Helens is the youngest volcanic peak in the Cascade Range. Most of the cone was produced so recently that glaciation has been slight. A 2,000-year-old mudflow believed to be of volcanic origin is present on the south flank. There have been 24 eruptions since 2500 B.C. (see Crandall and others, 1975), even though it was previously dormant for about 4,000 years. The later eruptions ranged from tephra and lahars to lava flows. The

Figure 1. View of Mount Hood from south, January 1974. Steam billows from Crater Rock, and several other fumaroles and hot spots maintain snow-free ground. (Photo by H. G. Schlicker)

Figure 2. View of Mount Baker from the southwest showing vapor plume rising 600 meters above Sherman Crater. (Photo by Austin Post, U.S. Geological Survey)

eruptions during the early 1800's produced lava domes, ash falls, and probable lava flows and are described briefly by Folsom (1970).

Mount Rainier

Mount Rainier is a large extensively glaciated stratovolcano with numerous large volcanically triggered mudflows dating back 5,000 years and more. The ages of pumice deposits range from about 100 to 150 years b.p., with some as old as 11,000 years. Fourteen sightings of volcanic activity on Mount Rainier were reported in the 19th century. Many have been discounted as dust or clouds, but an eruption of ash between 1820 and 1850 has been dated on the basis of tree rings. Future eruptions are likely within the next century.

Mount Baker

Mount Baker is a moderately dissected stratovolcano composed largely of successive layers of pyroxene andesite lavas of Pleistocene age (Coombs, 1939). The rocks forming the ancient volcanic center of the mountain have been dated by K-Ar methods to 400,000 ± 100,000 years b.p. (Easterbrook and Rahm, 1970). In a recent U.S. Geological Survey study examining the potential volcanic hazards of the area, Hyde and Crandell (1975) found post-glacial deposits establishing evidence for at least four eruptions of tephra, two episodes of lava flows, one of pyroclastic flow, and numerous mudflows occurring during the last 10,000 years. They report radiocarbon dates which limit the most recent tephra deposit on the east side of the peak to within the last few hundred years.

Historical reports suggest that the last eruptive period was probably in the mid-19th century. George Gibbs (1874), a geologist with the International Boundary Commission, reported Indian observations of volcanic ash and a large forest fire east of the mountain in 1843, as well as local miners' accounts of lava and an apparent lahar reaching the Baker River in 1858. This corresponds to the observations of residents of Victoria, B.C., who reported brightly illuminated eruption clouds over Mount Baker at night. Many other accounts of "eruptions" have been noted; however, they are quite vague and are unconfirmed (Malone and Frank, 1976).

Since the 1850's, fumarolic activity has been the prevalent volcanic expression. Mountaineering clubs, journals, and newspaper accounts have contained various descriptions of this activity over the past century; however, our most reliable source of information concerning the thermal activity has been aerial photography. Frank, Post, and Friedman (1975) analysed the progression of changes observed between 1940 and 1973 and reported recurrent debris avalanches.

Recent Observations on Mount Baker

A clear afternoon on March 10, 1975 afforded persons operating Upper Baker Dam their first glimpse of the summit of Mount Baker that spring. Their attention was soon focused on the large plume of dark-grey steam rising from the Sherman Crater (Figure 2) and what appeared to be ash staining the snow of the Boulder Glacier. Since then, an interdisciplinary effort, both ground-based and airborne, by various university and Federal agency scientists has documented the specific changes which have taken place in the Sherman Crater.

Initial aerial observations led to estimates of a 50 percent increase in the area of thermal activity over previous years. Because such occurrences may be indicative of forthcoming eruptions, a series of monitoring programs was inaugurated. A seismometer station was installed on the south rim of the crater on March 31 with a telemetry link to the University of Washington campus in Seattle. A continuous gas and temperature sensor was also installed, using the U.W. data link, and sulfur emissions and temperature variations were added to the continuous record.

In mid-April an infra-red thermographic image of the crater was used to spot the location of major fumarole clusters. Within the next few days, a circular depression in the snow surface, outlined by crevasses, collapsed, creating a 40-meter-deep perforation through the ice in which a shallow lake (about 60 meters in diameter) quickly formed. The dramatic rate of such large-scale changes within the crater underscored the desirability of visual and thermographic monitoring.

This concern prompted the Oregon Army National Guard and the Geography Department at OSU to undertake a cooperative remote sensing program. Beginning in mid-May, thermographic images were obtained at 10-day intervals using an infra-red line scanner aboard an OV-1 Mohawk aircraft. These aircraft, based at the Army Aviation Facility in Salem, Oregon, were also used to obtain aerial photographs at 20-day intervals. Special missions were also flown in response to signals from the ground-based monitors operated by University of Washington and U.S. Geological Survey scientists.

The monitoring program has two specific goals - to document the changes that occur within the crater area and to aid in the evaluation of potential hazards arising from both volcanic eruption or secondary effects such as mudflows, ash falls, or floods.

A photogrammetric model was constructed from stereo aerial photos obtained on July 12 for use as a photobase from which to monitor change. The total surface area of the crater was calculated to be 185,725 square meters, of which 35,230 square meters or 19 percent of the crater area was free of snow and ice. The infra-red thermograph of the same day indicated that 12,610 square meters, or nearly 1/3 of the snow-free area, was heated to temperatures exceeding 15°C.

Experiments were carried out using three different infra-red detectors with various spectral ranges, in addition to bandpass and cutoff filters:

Detector	Spectral range
1. Indium Antimonide (InSb)	1-6 mμ (4.5-5.5 peak response)
2. Mercury, Cadmium, Telluride (MCT)	8-14 mμ (10.0-13 peak response)
3. Indium Arsenide (InAs)	1-3.4 mμ (3-3.2 peak response)

Figure 3L shows the thermographic image obtained on July 12 using the MCT detector. The image shows a large anomalous area (>15°C.) but is obscured in some places by rising steam plumes. In order to pinpoint the location of major "hot-spots" and reduce the level of atmospheric attenuation by steam, the image obtained by the InAs detector (Figure 3R) was used. The differences in image resolution make simultaneous acquisition desirable, i.e., the MCT detector images pertinent terrain features which facilitates easy location of major anomalies, whereas the InAs detector resolves the exact location of fumarole vents. Therefore dual sensors were operated in a simultaneous mode.

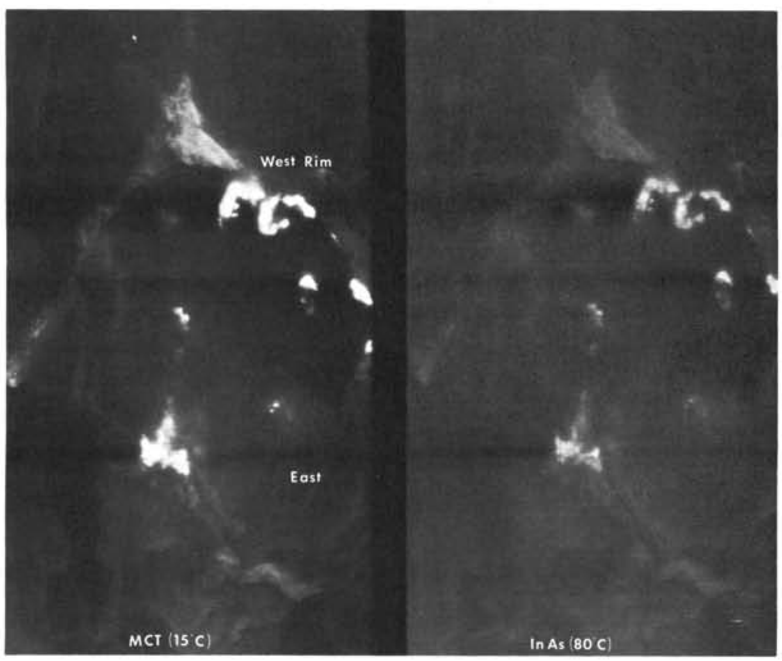
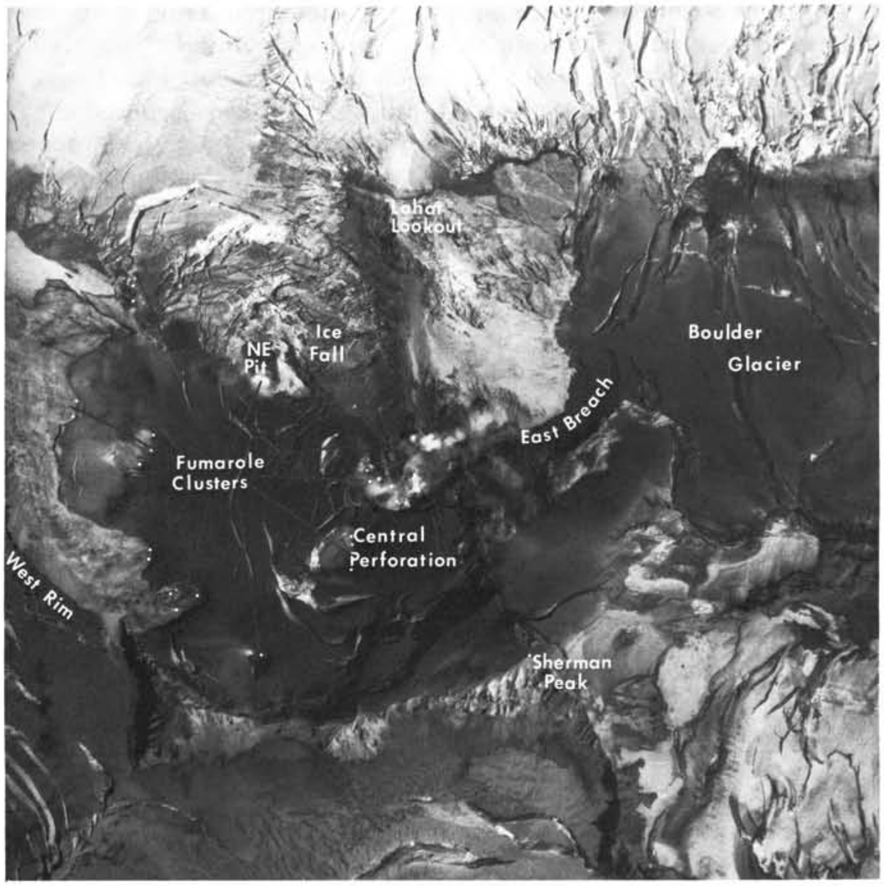
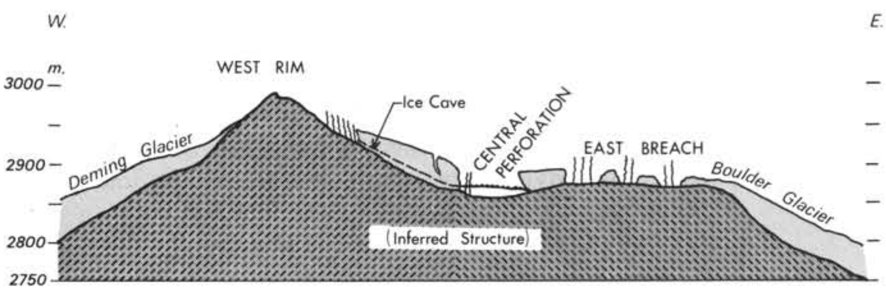


Figure 3. Infrared thermographs of Sherman Crater. Left: Mercury-cadmium-telluride detector (MCT) shows all heated ground above 15°C. Right: Indium-arsenide detector (InAs) shows only those active fumaroles with surface temperatures exceeding 80°C.



CROSSPROFILE OF SHERMAN CRATER



Cartography by Thomas W. Hodler

Figure 4. Key features of the Sherman Crater.

A log of all anomalies has been maintained and updated at 10-day intervals. Eleven major fumarole clusters have been visually identified (Figure 4), and each fumarole identified on the thermographs has been assigned to one of these clusters and its position has been "geo-coded" (labeled with reference to a geographic grid). As new "hot-spots" appear for the first time on the thermograph it is necessary to determine whether a new fumarole has been formed or a known one has melted a perforation through the crater ice. Helicopter and ground surveys have been used to evaluate the status of such "hot-spots," and the number of fumaroles confirmed for each cluster are listed in Table 1.

Table 1. Confirmed fumaroles

Cluster	No. of fumaroles	Density = $\frac{\text{No. of fumaroles}}{\text{area of anomaly } (m^2)}$
Central perforation	7	0.89
Northeast cluster	4	0.69
West cluster	23	1.17
Northwest cluster	8	0.45
North cluster	5	0.14
East breach	33	1.12
South rim	1	

As the change in the fumarole pattern is apparently related to ablation and ice motion within the crater, the panchromatic aerial photos were analysed at 20-day intervals to determine total snow cover and relative ice motion. Figure 5 is a map inferring ice motion within the crater from ice surface foliations and crevasse patterns imaged on July 12 and August 1. Arrows depict the direction of movement, and the width of the arrows indicates the mean rate of motion in millimeters per day.

Ice motion within the crater and the movement of glaciers flanking the mountain account for the only seismic activity yet monitored by the seismometer station on the crater's south rim. Gravity stations operated near the rim report a net gravity decrease of 0.4 m gals over the period from May 12 to September 19 when corrected for earth tides and ice melt. The lack of seismic evidence or tiltmeter observations confirming a pre-eruption swell hypothesis leaves the gravity observation open to speculation.

Observations and Conclusions

The dramatic increase of thermal activity about February 1975 in Sherman Crater has been the most significant volcanic change in the Cascades since the eruption of Mount Lassen in 1915.

While the shroud of winter has again obscured the peak in clouds and

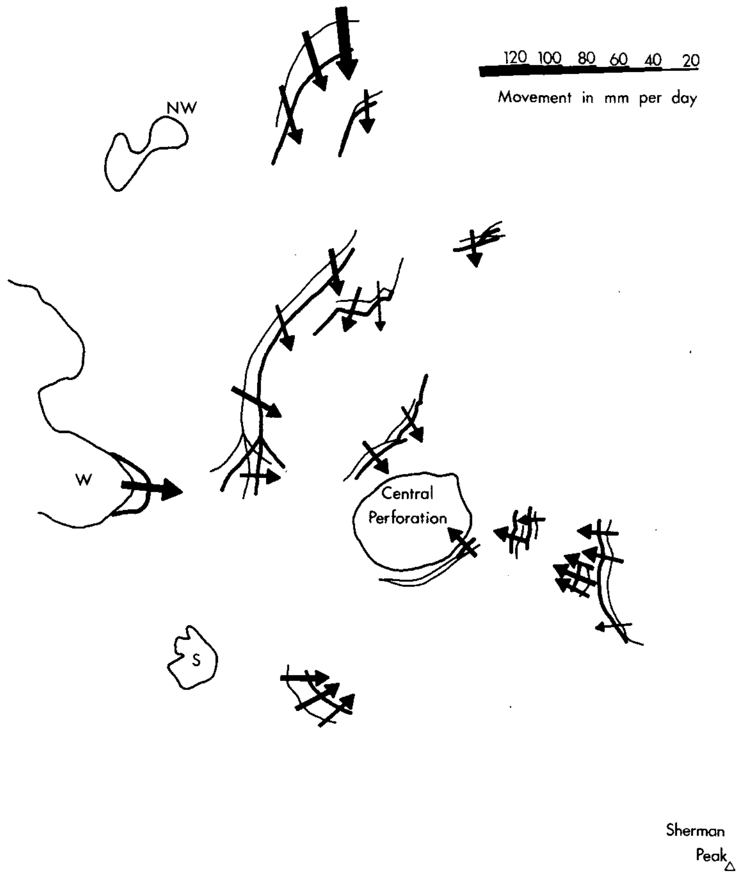


Figure 5. Relative motion of ice-surface foliations in Sherman Crater, July 12, 1975 to August 1, 1975.

covered it with heavy snows, scientists continue to monitor the volcanic activity. The seismometer and temperature sensors continue to telemeter information from the crater rim, although the snow has buried the gas sensor, and the Oregon Army National Guard continues to acquire infrared thermographs whenever flying conditions permit low-level overflights.

Aerial photographs, taken from one of the Mohawks on November 15, show that despite heavy snowfall nearly 13,000 square meters of the crater area remain snow free. This figure confirms the estimates of heated ground area provided by the thermographic imagery during the summer months. Several minor flooding incidents on Boulder Creek earlier this fall have been attributed to snow avalanches temporarily blocking the exit of the meltwater from the crater through the East Breach of the rim. Sulfuric water in dangerous concentrations frequently washes down the Boulder Creek drainage.

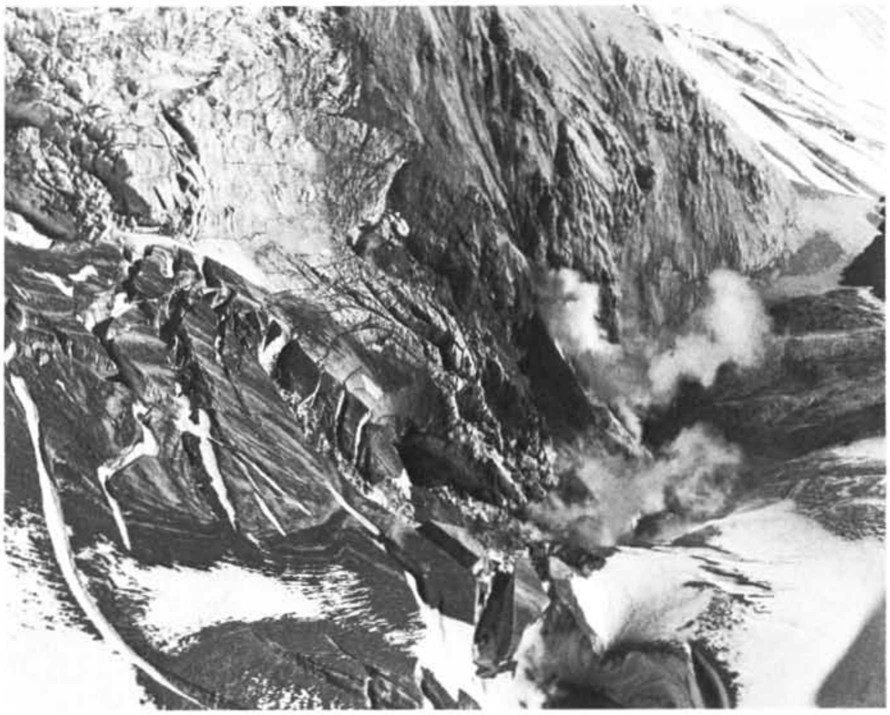


Figure 6. Breakup of ice within crater caused by rapid melting and the intense steam activity of East Breach. Note dark staining of ice surface.

The vapor plumes continue to rise unabated from the larger fumaroles, although little evidence exists to confirm the continued covering of the snow surface by particulate material (Figure 6). The dark material originally reported to be ash fall is actually hydrothermally altered rock and spherules of sulfur partially coated with pyrite crystals condensed from fumarolic gases and is not freshly ejected volcanic products (McLane and others, 1975) (stereo pair, Figure 7).

At the present time, infrared thermographic imagery of the Sherman Crater area is being computer enhanced to provide additional detail and to construct a heat-flow model of the fumarolic activity. In addition, the Oregon National Guard is conducting a series of infrared overflights of other known fumaroles on Cascade peaks in order to compare them to similar imagery obtained by the U.S. Geological Survey in 1973.

Not all of the observations point to possible increased volcanic activity. For example, all major volcanic eruptions throughout the globe have been associated with strong seismic shocks. On Mount Baker no geophysical

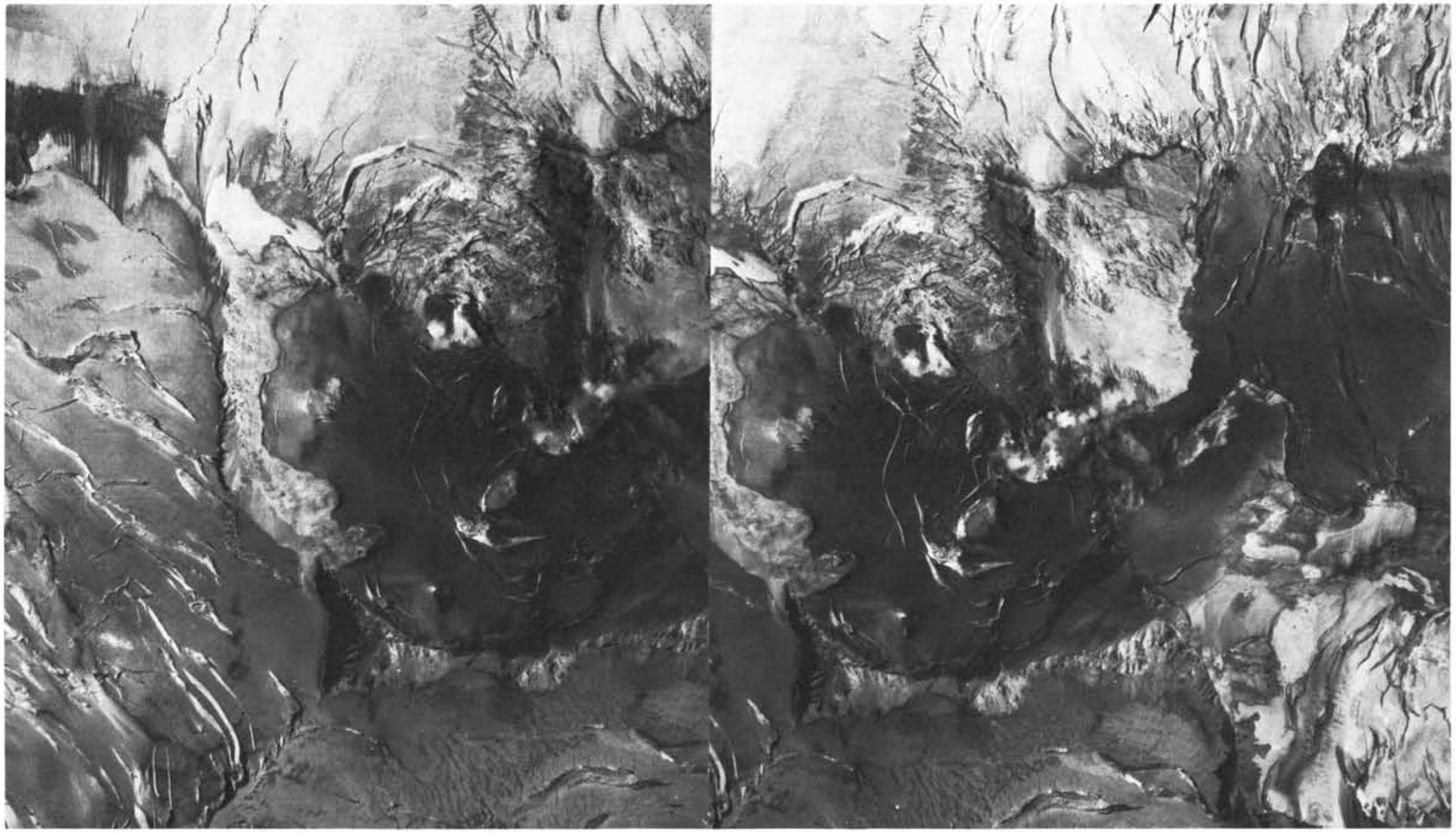


Figure 7. Stereopair of areal photos of the Sherman Crater area.

Figure 8. Photo of East Breach area and interior of Sherman Crater showing layering of stratovolcano in north wall (background), the Grant Peak icefall (upper right), and the unstable ash deposits of Lahar Lookout (foreground).

activity other than that attributed to ice movement at the surface has been detected by seismographs (Wash. Geologic Newsletter, July 1975). Studies on Hawaii showed a bulging of the surface caused by magmatic buildup prior to volcanic eruption. Tiltmeters installed on Mount Baker did not indicate volcanic swelling even though gravity stations near the rim did show a slight net gravity decrease. Since no tiltmeter indications or seismic activity accompanied the gravity decrease, its significance is not understood except to say it is probably not related to volcanic activity.

Although the primary hazard may not be a future full-scale eruption, the most immediate threat of danger exists from a possible mudflow caused by saturation of the volcanic ash and mudflow debris in Lahar Lookout (Figure 8).

Whether the thermal activity on Mount Baker will continue to increase toward an eruption, or rapidly fade away, the scientific interest which it has generated has focused our attention and furthered our understanding of yet another phase of volcanic activity in the High Cascades.

Acknowledgments

The authors wish to thank Major Loren Franke and the personnel of the 1042nd Military Intelligence Company (Aerial Surveillance) of the Oregon Army National Guard, Salem, for the acquisition of all imagery, and the Oregon Air National Guard for a subsequent overflight.

Bibliography

Coombs, H. A., 1939, Mount Baker, A Cascade volcano: Geol. Soc. America Bull., v. 50, p. 1493-1510.

Crandall, D. R., Mullineaux, D. R., and Rubin, M., 1975, Mount St. Helens volcano: recent and future behavior: Ore Bin, v. 37, no. 3, p. 41-48.

Easterbrook, D. J., and Rahm, D. A., 1970, Landforms of Washington: West. Wash. State Col., 156 p.

Folsom, M. M., 1970, Volcanic eruptions; the pioneers' attitude on the Pacific Coast from 1800 to 1875: Ore Bin, v. 32, no. 4, p. 61-71.

Frank, D., Post, A., and Freidman, J., 1975, Recurrent geothermally induced debris avalanches on Boulder Glacier, Mt. Baker, Washington: U.S. Geol. Survey Jour. Research, v. 3, p. 77-87.

Gibbs, G., 1874, Physical geography of the northwestern boundary of the United States: Jour. Amer. Geogr. Soc., v. 4, p. 298-302.

Hyde, J. H., and Crandell, D. R., 1975, Origin and age of post-glacial deposits and assessments of potential hazards from future eruptions of Mt. Baker: U.S. Geol. Survey open-file rpt. 75-286, 22 p.

Lawrence, D. B., 1948, Mt. Hood's latest eruption and glacier advances: Mazama, v. 30, no. 13.

Malone, S. D., and Frank, D., (1976, in press), Increased heat emission from Mount Baker, Washington: Submitted to EOS, July 1975.

McLane, J. E., Finkelman, R. B., and Larsen, R. R., 1975, Mineralogical examination of particulate matter from the fumaroles of Sherman Crater, Mt. Baker, Washington: Paper given 22nd Ann. Mtg., Pacific N.W. Region, Amer. Geophys. Union, Univ. of Wash., Seattle, Oct. 8-10, 1975.

Rosenfeld, C. L., 1975, Operational aerial surveillance of the Sherman Crater area, Mt. Baker, Washington: Paper given 22nd Ann. Mtg. Pacific N.W. Region, Amer. Geophys. Union, Univ. of Wash., Seattle, Oct. 8-10, 1975.

Washington Geologic Newsletter, 1975, Increased volcanic activity of Mount Baker, Washington: Wash. Div. Geol. and Earth Resources, v. 3, no. 3, p. 1-5, July.

* * * * *

OUR CHANGING RESOURCE CLIMATE

Ralph Mason
Deputy State Geologist
Oregon Dept. of Geology and Mineral Industries

The last Ice Age disappeared from the North American scene about 10,000 years ago. Since then the land has warmed, animal and plant life have flourished, and Man has moved in to dominate the scene, enjoy the good things of life - and sorely abuse the abundant natural economic reserves.

Now the first indications of another extended chilly period are beginning to appear. No long tongues of glacial ice a mile thick nor endless snowstorms are forecast, and, it is hoped, no unusually bad winters or cool summers will occur. But it will be a cold time for many people because the forms of energy used to heat buildings will be in short supply, electrical power may be severely curtailed, and the production of metals much reduced.

The New Ice Age actually started a few years ago when it became popular to consider land disturbance for productive effort as a bad show. Somehow we were supposed to abstain from logging and mining but provide housing for a growing population and all the worldly goods like TV's, autos, running water, medicines, and an endless list of other things we had become accustomed to.

Today, the results of this short sightedness are becoming clear. Industry has been hamstrung by restrictions and regulations which drain precious development funds into non-productive environmental improvement equipment and often force production cut-backs as well. The mining industry has been particularly hard hit since it can mine only where the minerals occur and must dig ever larger holes to mine lower and lower grade ore.

The climate for nearly every form of productive effort is steadily deteriorating. Even worse, the exploration and development of our economic resources have been decreased severely. There is, however, a great deal of planning and development of a vast array of social programs, which lay heavy stress on recreation and the quality of life rather than on the mundane problems of obtaining the resources vital to our existence.

Most of our mineral resources originate on Federal lands. The current rash of indiscriminate withdrawals from mineral entry or leasing has denied 70 percent of the Federal lands to any use by the mineral industry. With consumption of minerals and metals rapidly increasing, there should be an equally intensive effort to locate new resources. Unfortunately, just the opposite is true.

Over the years we have depended heavily on foreign resources to energize our economy. Now, with their reserves dwindling and their own consumption increasing, foreign countries are beginning to tighten up on mineral and fossil fuel exports. We will not only get less but pay far more for overseas resources.

The time lag in looking for, exploring, developing, and producing most mineral and energy resources ranges from 5 to 15 years. If our climate for accepting productive effort does not warm up very soon, we face the distinct possibility that it will get very cold – and stay that way for quite some time.

* * * * *

YOUR HOUSE COMES OUT OF A MINE

The raw material for the majority of the material used in building your home was furnished by the mining industry.

The foundation is probably concrete (limestone, clay, shale, gypsum, and aggregate mining).

The exterior walls may be made of brick (clay mining) or stone (dimension stone mining).

The insulation in the walls may be glass wool (silica, feldspar, and trona mining) or expanded vermiculite (vermiculite mining).

The interior walls are usually wallboard (gypsum mining).

The lumber in the structure will be fastened with nails and screws (iron ore mining and zinc mining).

If the roof is covered with asphalt shingles, the filler in the shingles is from a variety of colored silicate minerals from mining.

Your fireplace is probably of brick or stone, lined with a steel box (iron ore mining).

Your sewer piping is made of clay or iron pipe (clay mining or iron ore mining). Your water pipe is of iron ore or copper pipe (iron ore mining and copper mining).

Your electrical wiring is of copper or aluminum (copper mining or bauxite mining).

Your sanitary facilities are made of porcelain (clay mining).

Your plumbing fixtures are made of brass (copper and zinc mining), or stainless steel (nickel and chrome mining).

Your gutters of galvanized steel (iron ore mining and zinc mining).

The paint is manufactured with mineral fillers and pigments (from minerals obtained by mining).

Your windows are made of glass (trona, silica sand, and feldspar mining).

Your door knobs, locks, and hinges are of brass or steel (copper, zinc, and iron ore mining).

And finally your mortgage is written on paper made from wood or cloth fibers, but fibers filled with clay (from clay mining).

– Wallace Miner, February 12, 1976

* * * * *

FEDERAL MINERALS POLICY OUTLINED BY KLEPPE

Secretary of the Interior Thomas S. Kleppe, speaking before the American Mining Congress on January 20 said he will establish a clear policy for mineral production from Federal lands, and that policy will include a production requirement for coal leases or the lease will be terminated. Kleppe said that the Interior Department intends "to set new standards which would require diligent development - or relinquishment - of new or existing Federal coal leases. We are in the business of seeing that the Federal resources are produced for the nation's benefit." He predicted new battles over surface-mining legislation in Congress and said the issue must be settled before major increases in mining can occur. He went on to say, "However, in the absence of legislation, it is the Interior Department's intention to establish firm coal strip-mining regulations for the Federal lands."

Another new policy will be a new definition of "valuable deposits" that must be demonstrated in order to obtain noncompetitive Federal leases, instead of showing the presence of minable minerals. Kleppe proposed a definition which would require a showing that a "prudent person" would be economically justified in mining the minerals and would be likely to succeed.

Kleppe announced the formation of a Task Force on Mineral Withdrawals to determine the extent of restrictions on mineral development as a result of Federal withdrawals. He cited the Bennethum-Lee study (The ORE BIN, p. 164-165, Oct. 1975). He stressed that the "government must clarify its policies before the mining industry can effectively undertake its critical mission to increase America's mineral production." He said his audience "may not agree with all the decisions we reach, but we will make these decisions."

* * * * *

METALS AND MINERALS CONFERENCE IN APRIL

The 1976 Pacific Northwest Metals and Minerals Conference will be held April 8-10 at the North Shore Lodge in Coeur d'Alene, Idaho, with an expected attendance of between 300 and 400 mining professionals.

Marvin C. Chase, general chairman, reports that this year's theme will be "The Impending Mineral Crisis," with guest lecturers participating in sessions on: Exploration and geophysics; Energy, fuels, and nonmetallics; Geology; Extractive metallurgy; Land use and environment; and Mining. There will be nine field trips in northern Idaho and eastern Washington.

The conference is sponsored by the Columbia, Oregon, and North Pacific sections, American Inst. of Mining, Metal., and Petrol. Engineers.

For information and registration: 1976 Pacific N.W. Metals and Minerals Conference, Suite 216, North 7322 Division, Spokane, WA 99208.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order; postage free. All sales are final - no returns. Upon request, a complete list of Department publications, including out-of-print, will be mailed.)

BULLETINS

26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel.	$0.45
33.	Bibliography (1st suppl.) geology and mineral resources of Oregon, 1947: Allen .	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1964: Baldwin . . .	3.00
36.	Papers on Tertiary foraminifera: Cushman, Stewart & Stewart.	vol. 2-1.25
39.	Geology and mineralization of Morning mine region, 1948: Allen and Thayer . .	1.00
44.	Bibliography (2nd suppl.) geology and mineral resources of Oregon, 1953: Steere.	1.00
46.	Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch . . .	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	5.00
53.	Bibliography (3rd suppl.) geology and mineral resources of Oregon, 1962: Steere, Owen	3.00
57.	Lunar Geological Field Conf. guidebook, 1965: Peterson and Groh, editors . .	3.50
60.	Engineering geology of Tualatin Valley region, 1967: Schlicker and Deacon . .	7.50
61.	Gold and silver in Oregon, 1968: Brooks and Ramp	7.50
62.	Andesite Conference Guidebook, 1968: Dole	3.50
64.	Geology, mineral, and water resources of Oregon, 1969	3.00
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor (photocopy) . .	10.00
66.	Geology and mineral resources of Klamath and Lake Counties, 1970.	6.50
67.	Bibliography (4th suppl.) geology and mineral industries, 1970: Roberts . . .	3.00
68.	Seventeenth biennial report of the Department, 1968-1970	1.00
69.	Geology of the southwestern Oregon Coast, 1971: Dott	4.00
70.	Geologic formations of western Oregon, 1971: Beaulieu	2.00
71.	Geology of selected lava tubes in the Bend area, 1971: Greeley	2.50
72.	Geology of Mitchell quadrangle, Wheeler County, 1972: Oles and Enlows . .	3.00
73.	Geologic formations of eastern Oregon, 1972: Beaulieu	2.00
75.	Geology, mineral resources of Douglas County, 1972: Ramp	3.00
76.	Eighteenth biennial report of the Department, 1970-1972	1.00
77.	Geologic field trips in northern Oregon and southern Washington, 1973. . . .	5.00
78.	Bibliography (5th suppl.) geology and mineral industries, 1973: Roberts and others	3.00
79.	Environmental geology inland Tillamook Clatsop Counties, 1973: Beaulieu. . .	7.00
80.	Geology and mineral resources of Coos County, 1973: Baldwin and others . . .	6.00
81.	Environmental geology of Lincoln County, 1973: Schlicker and others	9.00
82.	Geol. Hazards of Bull Run Watershed, Mult. Clackamas Counties, 1974: Beaulieu	6.50
83.	Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00
84.	Environmental geology of western Linn Co., 1974: Beaulieu and others. . . .	9.00
85.	Environmental geology of coastal Lane Co., 1974: Schlicker and others . . .	9.00
86.	Nineteenth biennial report of the Department, 1972-1974	1.00
87.	Environmental geology of western Coos and Douglas Counties, Oregon, 1975 . .	9.00
88.	Geology and mineral resources of upper Chetco River drainage, 1975: Ramp . .	4.00

GEOLOGIC MAPS

Geologic map of Oregon west of 121st meridian, 1961: Wells and Peck $2.00; mailed -	2.50
Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Geologic map of Albany quadrangle, Oregon, 1953: Allison (from Bulletin 37) . . .	1.00
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.50
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	1.50
Geologic map of Bend quadrangle, and portion of High Cascade Mtns., 1957: Williams	1.50
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka	2.00
GMS-2: Geologic map, Mitchell Butte quadrangle, Oregon: 1962	2.00
GMS-3: Preliminary geologic map, Durkee quadrangle, Oregon, 1967: Prostka . .	2.00
GMS-4: Gravity maps, Oregon onshore & offshore; [set only]: at counter $3.00, mailed	3.50
GMS-5: Geology of the Powers quadrangle, 1971: Baldwin and Hess	2.00
GMS-6: Preliminary report, geology of part of Snake River Canyon, 1974: Vallier. .	6.50

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

The Ore Bin

Available Publications, Continued:

SHORT PAPERS

18. Radioactive minerals prospectors should know, 1955: White and Schafer $0.30
19. Brick and tile industry in Oregon, 1949: Allen and Mason 0.20
21. Lightweight aggregate industry in Oregon, 1951: Mason 0.25
24. The Almeda mine, Josephine County, Oregon, 1967: Libbey 3.00
25. Petrography, type Rattlesnake Fm., central Oregon, 1976: Enlows . . . . . in prep

MISCELLANEOUS PAPERS

1. Description of some Oregon rocks and minerals, 1950: Dole 1.00
2. Oregon mineral deposits map (22 x 34 inches) and key (reprinted 1973): 1.00
5. Oregon's gold placers (reprints), 1954 . . . . 0.50
6. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton 3.00
7. Bibliography of theses on Oregon geology, 1959: Schlicker 0.50
   (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts 0.50
8. Available well records of oil and gas exploration in Oregon, rev. 1973: Newton . 1.00
11. A collection of articles on meteorites, 1968 (reprints from The ORE BIN) . . . 1.50
12. Index to published geologic mapping in Oregon, 1968: Corcoran 0.50
13. Index to The ORE BIN, 1950-1974. . . . . 1.50
14. Thermal springs and wells, 1970: Bowen and Peterson 1.50
15. Quicksilver deposits in Oregon, 1971: Brooks 1.50
16. Mosaic of Oregon from ERTS-1 imagery, 1973: 2.50
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975 . . . 2.00

OIL AND GAS INVESTIGATIONS

1. Petroleum geology, western Snake River basin, 1963: Newton and Corcoran . . . 3.50
2. Subsurface geology, lower Columbia and Willamette basins, 1969: Newton . . . 3.50
3. Prelim. identifications of foraminifera, General Petroleum Long Bell No. 1 well . . 2.00
4. Prelim. identifications of foraminifera, E. M. Warren Coos Co. 1-7 well: Rau . . 2.00

MISCELLANEOUS PUBLICATIONS

Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 . . . . 0.25
Mining claims (State laws governing quartz and placer claims) 0.50
Oregon base map (22" x 30"). 0.50
Geologic time chart for Oregon, 1961 10
Postcard - geology of Oregon, in color . . . . 10¢ each; 3 - 25¢; 7 - 50¢; 15 - 1.00
The ORE BIN - Annual subscription . . . . ($8.00 for 3 yrs.) 3.00
   Available back issues, each . . . . 25¢; mailed 0.35
   Accumulated index - see Misc. Paper 13

GOLD AND MONEY SESSION PROCEEDINGS

Second Gold and Money Session, 1963 [G-2] 2.00
Third Gold and Money Session, 1967 [G-3] 2.00
G-4 Fifth Gold and Money Session, Gold Technical Session 5.00