

Fact Sheets—An Effective Aid to Interpretation of Natural Features in National Parks

**A poster presentation at
“West by Northwest”
Resource Management and Interpretation
Workshop
National Park Service, Pacific West Region
March 13-17, 2000
Hanalei Hotel, San Diego, CA**

**M.A. Clynne¹,
J.W. Hendley II²,
and P.H. Stauffer²**

**U.S. Geological Survey
345 Middlefield Road MS910
Menlo Park, CA 94025**

**¹ Volcano Hazards Team
² Western Publications Group**

**mclynnne@usgs.gov
(650) 329-5236**

Abstract

A relatively new concept to make the latest scientific information accessible to the public is to combine U.S. Geological Survey (USGS) Earth and biological science with National Park Service (NPS) interpretation. Because staff in National Parks often lack extensive expertise in Earth science, they typically rely on published information from scientific or popular literature for geological interpretation. Unfortunately, much of this information is highly technical, biased, incorrect, or out of date. One solution to this problem is to promote joint publication of "Fact Sheets," concise, 2- or 4-page, well-illustrated interpretations of specific natural science topics. Fact Sheets are an effective means of quickly and clearly communicating scientific explanations of Park features to the public. Readers of these publications learn how to better understand the natural wonders of Parks. Careful review and edit are especially important with such Fact Sheets because they must present a clear, unambiguous message to the visitor.

Introduction

The U.S. Geological Survey (USGS) has made public outreach and Earth science education primary goals and uses "Fact Sheets" as part its established outreach program. In most national parks, even those that were established to protect and showcase significant geologic features, the National Park Service (NPS) has no geologist on staff to assist in developing and maintaining geologic exhibits. For many years, USGS geologists working in the Parks have had informal arrangements to transfer information to park staff for dissemination to the public. To further this goal, the Volcano Hazards Team of the USGS has begun jointly publishing a series of Fact Sheets with the NPS about volcanic features in national parks. This series, the first of which describe volcanoes in Lassen Volcanic National Park, is expected to be only the beginning of a broader program of joint Fact Sheets for the public.

Fact Sheets further several goals:

- applying USGS scientific expertise to interpretation of geologic features in national parks
- supplying data to NPS naturalist staff on advancements in the understanding of geology in individual parks
- promoting interaction between USGS scientists and NPS interpreters to develop outreach materials for park visitors
- educating the public directly on park geology

Fact Sheets are a powerful tool for information transfer:

- they are concise, easy to read, and can be produced quickly
- they make accessible the most up-to-date information on park geology—many interpreters are unaware of the latest discoveries because they are unpublished or only published in technical literature
- they are the result of collaboration between geologists and interpreters, making the best use of each others expertise
- fact sheets jointly produced with NPS are peer reviewed and edited and illustrated for the public by USGS technical production staff

The two main types of Fact Sheets:

- a more technical fact sheet that brings a higher level of science to a focussed topic, typically 2 (but can be 4) pages in one color
- a less technical fact sheet with a more general presentation style, typically 2 (but can be 4) pages in full color

Essential Elements of a Good Fact Sheet:

- Good science
- Short, active, and non-technical title
- Attention-grabbing introduction (usually a story)
- Clear, concise message that readers can relate to
- Eye-catching and effective graphics

Fact Sheet examples:

The fact sheet format is flexible and can accommodate a wide variety of topics and styles of presentation. Here are two examples of recently produced fact sheets for Lassen Volcanic National Park.

Eruptions of Lassen Peak, California, 1914 to 1917

The Devastated Area on the northern flank of Lassen Peak was the site of a catastrophic eruption in May 1915. This eruption was the reason for creating Lassen Volcanic National Park, and the Devastated Area is one of the major attractions in the park. Until recently, the interpretation of this eruption relied on information acquired before 1935. Because there have been many advances in the science of volcanology, this information was seriously out of date, and much was incorrect. The 1914-1917 eruptive sequence had several unique facets, and this Fact Sheet makes available new interpretations of those events. It contains enough science to guide naturalists' presentations, but not so much that non-geologists are overwhelmed, and also provides visitors more complete information than is available in NPS displays.

How Old is "Cinder Cone"?--Solving a Mystery in Lassen Volcanic National Park, California

On the basis of "eyewitness" accounts from the 1850's, Cinder Cone, a volcano in Lassen Volcanic National Park, was thought to have last erupted in 1850-1. Interpretations of its history have been varied and complex, some involving as many as 5 eruptions over 300 hundred years, culminating in 1851. However, recent work by USGS geologists at Cinder Cone has unequivocally refuted the 1851 eruption. This fact sheet is the first official presentation of a new interpretation of the formation of Cinder Cone. Here the science is less technical than in the *Eruptions of Lassen Peak* fact sheet, and is presented within the historical framework of the evolving understanding of Cinder Cone and the personalities involved. It is intended to supplement the NPS trail guide at Cinder Cone.

USGS Volcano Hazards Team-Lassen Volcanic National Park cooperation

The USGS and NPS have long recognized the problems of interpreting geology in parks. Several years ago the Volcano Hazards Team proposed and Lassen Volcanic National Park (LVNP) agreed to collaborate on a series of fact sheets to interpret park geology. Park naturalists select the topics, USGS scientists and editorial staff write the text and provide the layout. Input and review from NPS naturalists occurs at all steps in the process. The two examples illustrated above are the first of at least five Fact Sheets for LVNP (Fact Sheets on Lassen's history of volcanism, hydrothermal system, and volcano hazards are in preparation). We hope that this model of cooperation between USGS scientists and NPS naturalists will spread throughout national parks with geologic themes.

Conclusion

The USGS has made public outreach and earth science education primary goals. A fundamental aspect of the NPS mandate is information transfer to park visitors. Joint NPS/USGS interpretive products for increasing public awareness of the natural resources in national parks seems like a hand-in-glove fit. Fact sheets are a powerful tool for accomplishing these compatible goals.

U.S. GEOLOGICAL SURVEY and the NATIONAL PARK SERVICE—OUR VOLCANIC PUBLIC LANDS

Eruptions of Lassen Peak, California, 1914 to 1917

On May 22, 1915, an explosive eruption at Lassen Peak, California, the southernmost active volcano in the Cascade Range, devastated nearby areas and rained volcanic ash as far away as 200 miles to the east. This explosion was the most powerful in a 1914–17 series of eruptions that were the last to occur in the Cascades before the 1980 eruption of Mount St. Helens, Washington. Recent work by scientists with the U.S. Geological Survey (USGS) in cooperation with the National Park Service is shedding new light on these eruptions.

Lassen Peak is the largest of a group of more than 30 volcanic domes erupted over the past 300,000 years in Lassen Volcanic National Park in northern California. These mound-shaped accumulations of volcanic rock, called lava domes, were created by eruptions of lava too viscous to readily flow away from its source. Eruptions about 27,000 years ago formed Lassen Peak, probably within only a few years. With a height of 2,000 feet and a volume of half a cubic mile, it is one of the largest lava domes on Earth.

When Lassen Peak formed, it looked much like the nearby 1,100-year-old Chaos Crags Domes, with steep sides covered with angular



The May 22, 1915, explosive eruption of Lassen Peak, California, blasted rock fragments and pumice high into the air and rained fine volcanic ash as far away as Winnemucca, Nevada, 200 miles to the east. In this photograph taken from near the town of Red Bluff, 40 miles west of the volcano, the huge column of volcanic ash and gas produced by the eruption rises to a height of more than 30,000 feet. (Photograph by R.E. Stinson, courtesy of the National Park Service.)

rock talus. However, from 25,000 to 18,000 years ago, during the last ice age, Lassen's shape was significantly altered by glacial erosion. For example, the bowl-shaped depression on the volcano's northeastern flank, called a cirque, was

eroded by a glacier that extended out 7 miles from the dome.

Initial Rumbblings (May 1914 to May 1915)

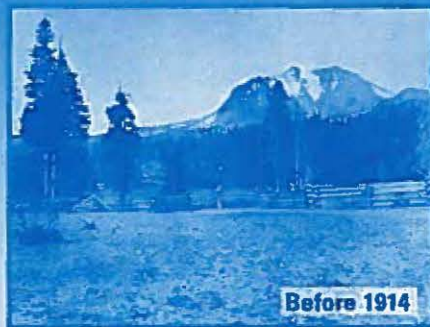
On May 30, 1914, Lassen Peak awoke from a 27,000-year-long slumber when it was shaken by a steam explosion. Such steam blasts occur when molten rock (magma) rises toward the surface of a volcano and heats shallow ground water. The hot water rises under pressure through cracks and, on nearing the surface, vaporizes and vents explosively.

By mid-May 1915, more than 180 steam explosions had blasted out a 1,000-foot-wide crater near the summit of Lassen Peak. Then the character of the eruption changed dramatically. On the evening of May 14, 1915, incandescent blocks of lava could be seen bouncing down the flanks of Lassen from as far away as the town of Manton, 20 miles to the west. By the next morning, a growing dome of dacite lava (lava containing 63 to 68% silica) had welled up into the volcano's crater and filled it.

Events of May 19–20, 1915

Late on the evening of May 19, a large steam explosion shattered the dacite dome, creating a new crater at the summit of Lassen Peak. No new magma was ejected in this explosion, but glowing blocks of hot lava from the dome fell on the summit and snow-covered upper flanks of Lassen Peak.

DEVASTATION CAUSED BY THE MAY 1915 ERUPTIONS



Before 1914



June 1915

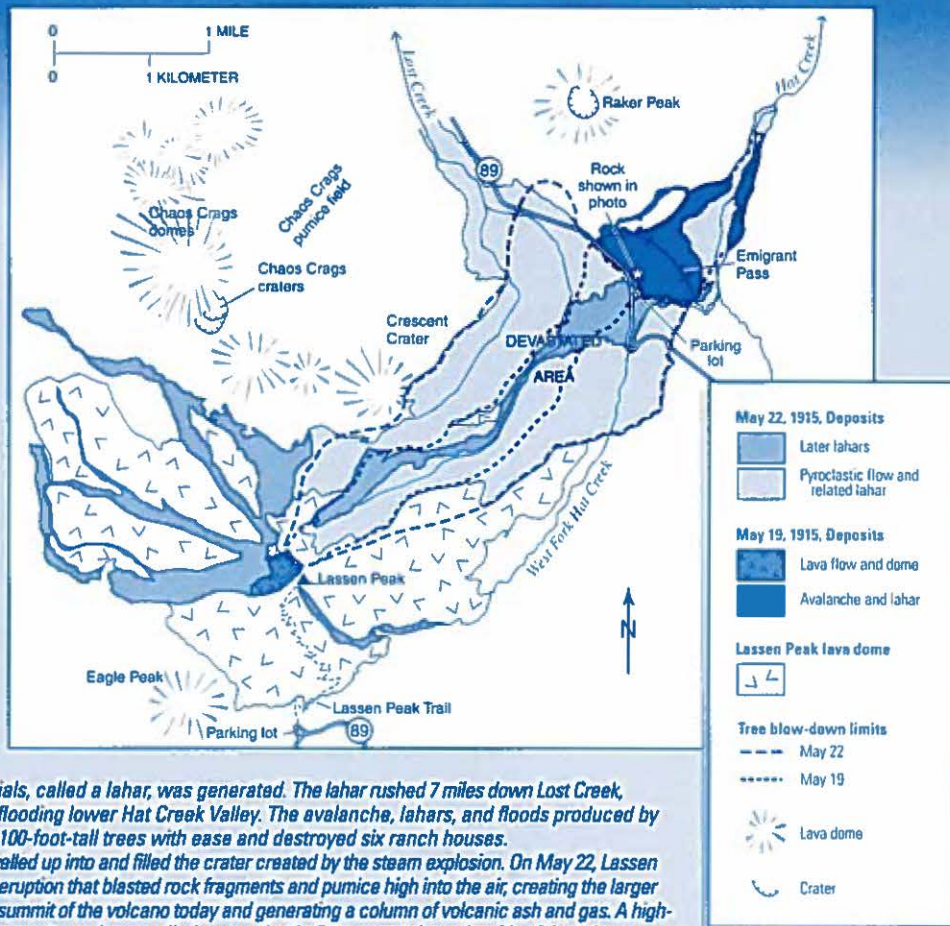
The 1914–17 series of explosive eruptions at Lassen Peak, California, were among the first volcanic eruptions to be extensively photographed, largely by Benjamin Franklin Loomis, a local businessman and amateur photographer. As shown in the left photograph, the northeastern flank of Lassen Peak was covered by mature conifer forest before 1914. The photograph on the right, taken by Loomis in June 1915 from nearly the same location, shows the devastation caused by the two most powerful eruptions in the series, those of May 19 and 22 of that year. The large rock in the foreground is a piece of the lava dome that filled Lassen's summit crater during the week before the May 19 eruption and was carried to its present location by the avalanche caused by this eruption. Today, this rock can be seen on the Devastated Area Interpretive Trail. The appearance of Lassen's northeastern flank was little changed for 50 years after the eruptions, while seedlings struggled to regain a foothold, but today young vigorously growing trees are obscuring the devastation and reclaiming the area as forest. (Photographs courtesy of the National Park Service.)

GENERALIZED MAP OF DEPOSITS FROM LASSEN PEAK'S MAY 1915 ERUPTIONS



The May 1915 eruptions of Lassen Peak destroyed a 3-square-mile area, now called the Devastated Area, on the flank of the volcano. On the evening of May 19, a large steam explosion shattered the still-hot lava dome that had filled Lassen's summit crater during the previous week, blasting out a new crater at the volcano's summit and creating an avalanche of hot lava blocks, volcanic debris, and snow. As the snow melted, a huge mudflow of volcanic materials, called a lahar, was generated. The lahar rushed 7 miles down Lost Creek, where it released huge volumes of water, flooding lower Hat Creek Valley. The avalanche, lahars, and floods produced by this explosion uprooted and carried away 100-foot-tall trees with ease and destroyed six ranch houses.

During the night of May 19-20, new lava welled up into and filled the crater created by the steam explosion. On May 22, Lassen Peak exploded again in a powerful climactic eruption that blasted rock fragments and pumice high into the air, creating the larger and deeper of the two craters seen near the summit of the volcano today and generating a column of volcanic ash and gas. A high-speed avalanche of hot ash, pumice, rock fragments, and gas, called a pyroclastic flow, swept down the side of the volcano. Trees that were still standing after the May 19 eruption were blown down, with their trunks left lying on the ground pointing away from the volcano. The pyroclastic flow rapidly melted snow in its path, creating a lahar that followed the path of the lahar 2 days earlier and rushed down Lost Creek to Old Station, releasing water that again flooded lower Hat Creek Valley.



These falling blocks launched a half-mile-wide avalanche of snow and volcanic rock that roared 4 miles down the volcano's steep northeast flank and over a low ridge at Emigrant Pass into Hat Creek.

As the hot lava blocks broke into smaller fragments, the snow melted, generating a mudflow of volcanic materials, called a lahar. The bulk of this lahar was deflected northwestward at Emigrant Pass and flowed 7 miles down Lost Creek. Even after coming to rest, both the avalanche and lahar released huge volumes of water, flooding lower Hat Creek Valley during the early morning hours of May 20. The lahar and flood destroyed six mostly not-yet-occupied summer ranch houses. Fortunately, the few people in these houses escaped with only minor injuries.

Also during the night of May 19-20, dacite lava somewhat more fluid than that erupted during the previous week welled up into and filled the new crater at Lassen's summit, spilled over low spots on its rim, and flowed 1,000 feet down the steep west and northeast flanks of the volcano.

Climactic Eruption of May 22, 1915

Late on the afternoon of May 22, after two quiet days, Lassen Peak exploded in a powerful eruption that blasted rock fragments and pumice high into the air, creating the larger and deeper of the two craters seen near the summit of the volcano today. A huge column of volcanic ash and gas rose more than

30,000 feet into the air and was visible from as far away as Eureka, 150 miles to the west.

Pumice falling onto the northeastern slope of Lassen Peak generated a high-speed avalanche of hot ash, pumice, rock fragments, and gas, called a pyroclastic flow, that swept down the side of the volcano, devastating a 3-square-mile area. The pyroclastic flow rapidly incorporated and melted snow in its path. The water from the melted snow transformed the flow into a highly fluid lahar that followed the path of the May 19-20 lahar and rushed nearly 10 miles down Lost Creek to Old Station. This new lahar released a large volume of water that flooded lower Hat Creek Valley a second time.

The powerful climactic eruption of May 22 also swept away the northeast lobe of the lava flow extruded 2 days earlier. The eruption produced smaller mudflows on all flanks of Lassen Peak, deposited a layer of pumice and volcanic ash traceable for 25 miles to the northeast, and rained fine ash at least as far away as Winnemucca, Nevada, 200 miles to the east.

Continuing Volcanic Activity and Future Eruptions

For several years after the May 22, 1915, eruption, spring snowmelt percolating down into Lassen Peak triggered steam explosions, indicating that rocks beneath the volcano's surface remained hot. Particularly vigorous steam explosions in May 1917 blasted out the second of the

two craters now seen near the volcano's summit. Steam vents could be found in the area of these craters into the 1950's but gradually waned and are difficult to locate today. Lassen Peak sleeps again, but active steam vents, hot springs, and bubbling pools of hot mud are still found elsewhere in Lassen Volcanic National Park. No one can say when, but it is almost certain that the Lassen area will experience volcanic eruptions again.

Michael A. Clynné, Robert L. Christiansen, Tracey J. Felger,
Peter H. Stauffer, and James W. Hendley II

Graphic design by
Sara Boore and Susan Mayfield
Banner design by Bobbie Myers and Sara Boore

COOPERATING ORGANIZATIONS
Lassen Loomis Museum Association
National Park Service
U.S. Forest Service

For more information contact:
Lassen Volcanic National Park
P.O. Box 100, Mineral, CA 96063
(530) 595-4444
<http://www.nps.gov/lavo/>
or
<http://volcanoes.usgs.gov/>

See also *Living With Volcanic Risk in the Cascades* (USGS Fact Sheet 165-97), *What are Volcano Hazards?* (USGS Fact Sheet 002-97), and *Pictorial History of the Lassen Volcano* by Benjamin Franklin Loomis (1926, re-published by the Lassen Loomis Museum Association).

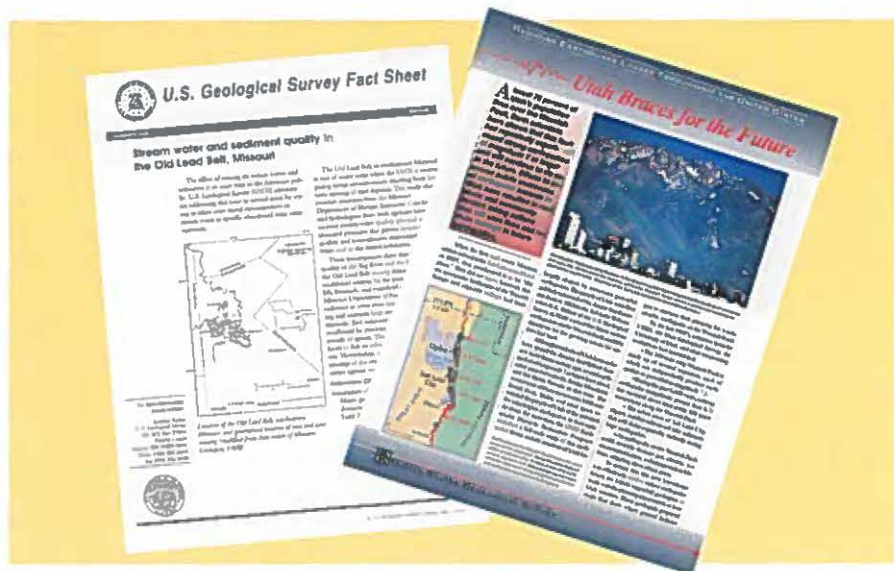
Creating an Effective Fact Sheet

Fact Sheets are a powerful way for USGS scientists to rapidly communicate the results of their work directly to the public. These concise official publications can be particularly useful in helping readers understand and live with natural hazards. Fact Sheets also increase public awareness of the USGS' role. Careful review and edit are especially important with Fact Sheets because they often touch on sensitive issues and must present a clear, unambiguous message to the general public.

The mission of the U.S. Geological Survey (USGS) is to provide the Nation unbiased scientific information about our restless and environmentally fragile planet. The results of USGS work are used by policymakers, private industry, and the general public. Because of their technical nature, however, many USGS publications do not convey a clear message to the non-scientist.

Fact Sheets, an official publication series of the USGS since 1994, are proving effective in fulfilling this important part of our mission. For example, these concise publications can be powerful tools for directly alerting the public to natural hazards—enabling readers to better prepare themselves and also allaying unwarranted fears.

As with other USGS publication series, Fact Sheets must go through the official approval process, including review, editing, and Director's approval. Because they often touch on sensitive issues and must present a clear, unambiguous message to the public, a thorough process of review and editing is especially important for Fact Sheets.



No matter how well written, a Fact Sheet will not convey its message unless it is picked up and read. In publications intended for a general audience, the importance of color and format cannot be overstated. An attractively formatted, color Fact Sheet with a striking illustration on the first page is far more likely to be picked up and read by a member of the public than is a plainer looking black-and-white product. Colorful illustrations, an interesting format, and a bold, active title help capture the viewer's attention at a quick glance.

Essential Elements of a Good Fact Sheet

- Good science
- Title (must be short, active, and non-technical)
- Brief abstract
- Attention-grabbing introduction (usually a story)
- Clear, concise message that readers can relate to
- Well-explained benefit to society
- Point of contact for more information
- Eye-catching, effective graphics (color is a must)
- Format that identifies it as a USGS product

What Authors Need To Provide

- **DRAFT TEXT** (1,500–2,000 words for a 2-page Fact Sheet)—Initially, authors should not worry too much about length or the use of technical terms; culling a more detailed text and rewording it for the general public is easier than filling gaps in an incomplete text. Editors can greatly assist authors by doing substantial rewriting and can help craft an attention-grabbing introduction.
- **GRAPHIC MATERIAL**—Illustrations may include photographs (those showing people actively working are particularly good), small maps, technical diagrams, and sketches. Editors and graphic artists can help produce easily

understood graphics from technical illustrations or even from rough ideas or sketches.

- **CONSULTATION**—Frequent consultation is required between authors, editors, and graphic artists. An effective Fact Sheet is usually the product of extensive interaction and feedback.

About the Process

- **REVISE! REVISE! REVISE!**—Expect the text, captions, and illustrations to go through many successive versions, bouncing back and forth among editors, authors, graphic artists, and reviewers. Much of the writing, editing, reviewing, and “polishing” occurs concurrently. Captions often reach final form last, after the graphics are completed.
- **TEAMWORK**—Every phrase in a Fact Sheet must be carefully considered to ensure that it can be clearly understood, cannot be misread, and conveys no unintended meanings to the non-technical reader. Experience has shown that the synergy of people working together not only results in higher quality but also saves time. For example, a team of

SYNERGY FUELS THE CREATION OF EFFECTIVE FACT SHEETS



REVIEWERS INCLUDE

- Technical reviewers
- Test readers
- Publications Group Chief (final review and Director's approval)

Creating an effective Fact Sheet for the general public involves many revisions and much teamwork. Every aspect of a Fact Sheet must be carefully considered to ensure that it will be clearly understood by the non-scientist reader. Roundtable discussions and bouncing successive revisions among team members produces a synergy that not only results in higher quality but also saves time.

two editors rewriting and "polishing" the text of a Fact Sheet at the same computer monitor has proved more time-effective than a single editor working alone. Roundtable discussions between the authors, editors, and graphic artists are also very productive.

- **REVIEW & TEST MARKETING**—Different eyes see different things, so you almost cannot have too many people read and review a Fact Sheet. For example, each of the 13 Fact Sheets in the series *Reducing Earthquake Losses Throughout the United States* (produced in 1995 and 1996) was routinely reviewed several times by 7 to 11 people, including editors, graphic artists, authors, series coordinators, and the Publications Group Chief. All of them found some way to improve each Fact Sheet. In addition, many of the Fact Sheets were reviewed by non-scientists outside the USGS (often family members); the comments of these "test readers" from the general public often also resulted in significant improvements.

General Tips

- **COLOR! COLOR! COLOR!**—Black and white just doesn't do it. Tasteful and effective use of color makes it more likely that the general public will pick up a publication and read it. Some black-and-white images can be successfully incorporated, but color is the attractant.

- **BANNER HEAD**—A series banner head above the Fact Sheet's title is a good way to tell the reader the general subject area being discussed. Future related Fact Sheets can then be placed in the same series. A simple graphic symbol appropriate to the series subject may accompany the banner head and title.
- **"SPEAK PLAINLY"**—Because Fact Sheets intended for the public must be easily understood by a broad audience, text should be written for a high-school ("National Geographic") reading level. Technical terms should be used only if absolutely essential to convey the meaning, and any technical term used must be explained clearly.
- **CONCISENESS**—For a 2-page Fact Sheet, the final abstract should be about 70 words or less, and the final text (excluding captions) about 1,000 words or less. To achieve the required conciseness, eliminate anything that is not necessary. As you read the information contained in the text, ask yourself, "Will the public really care about this?" If the answer is "No," either delete the particular item or, if it is essential to the story, make it relevant. Subheadings and bullet items are rarely used (because they require extra space) but may be appropriate for some topics, as with this Fact Sheet.
- **ABSTRACT & CAPTIONS**—Because some people will only read the abstract and cap-

tions and look at the illustrations, these elements should carry the essentials of the message contained in the Fact Sheet. Captions may therefore purposely repeat portions of the text, sometimes verbatim.

- **COOPERATORS**—When appropriate, non-USGS organizations and groups involved in the work discussed in the Fact Sheet can be listed under "Cooperating Organizations," usually following the names of authors and graphic designers.
- **POINT OF CONTACT**—So that the interested reader can get more information on the topic presented, a point of contact should be given at the end of each Fact Sheet. Include a telephone number, mailing address, and e-mail and (or) website address. Because people's assignments change, it is best not to give a person's name as the point of contact. An 800 telephone number is best, and the caller should be able to talk to someone immediately or leave a message that will receive a prompt response. If appropriate, reference can be made to related Fact Sheets.

Fact Sheets created through the intensive review and editing process outlined here are already reaching a broad audience. Public demand has been so high for these products that most have been reprinted within months of publication, even with initial printings of 10,000 copies each. By using effective products such as these Fact Sheets, USGS scientists can bring the benefits of their work more directly to the citizens of our Nation.

Peter H. Stauffer and James W. Hendley II

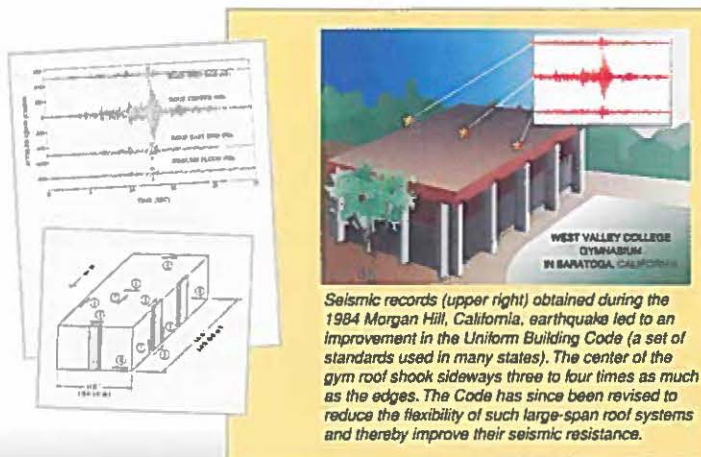
Graphic design by
Susan Mayfield and Sara Boore

For more information contact:

Western Publications Group (415) 329-5038
U.S. Geological Survey, Mail Stop 951
345 Middlefield Road, Menlo Park, CA 94025
URL: <http://geodata.wr.usgs.gov/>

U.S. Geological Survey Fact Sheet-008-97
1997

As shown by these diagrams and the final Fact Sheet illustration derived from them, editors and graphic artists can produce attractive, easily understood images from highly technical material or even from rough ideas or sketches.



How Old is “Cinder Cone”?—Solving a Mystery in Lassen Volcanic National Park, California

Cinder Cone in Lassen Volcanic National Park is a 700-foot-high volcanic cone. Its age has been controversial since the 1870's, when many people thought it was only a few decades old. Later, the cone and associated lava flows were thought to have formed about A.D. 1700 or during a 300-year-long series of eruptions ending in 1851. However, recent studies by U.S. Geological Survey (USGS) scientists, working in cooperation with the National Park Service to better understand volcano hazards in the Lassen area, have firmly established that Cinder Cone was formed in eruptions about 1650.

After traveling through northern California in the spring of 1851, two gold prospectors reported seeing an erupting volcano that “threw up fire to a terrible height.” They further claimed that they walked 10 miles over rocks so hot that their boots were entirely destroyed. Their story is only one of several reports from that time that were later assumed to describe an eruption of “Cinder Cone,” a volcanic feature located in what is now the northeast corner of Lassen Volcanic National Park.

Cinder Cone is a 700-foot-high cone of loose scoria. Scoria forms when blobs of gas-charged lava are thrown into the air during an eruption and cool in flight, falling as dark volcanic rock containing cavities created by trapped gas bubbles. The summit of Cinder Cone has a crater with a double rim, probably created by fluctuating eruptive activity late in its formation. The cone also has several associated blocky lava flows, and a related, widespread ash deposit identifiable for 8 to 10 miles from the cone.

There are actually two scoria cones at Cinder Cone—the remnants of a nearly completely



This striking view to the southeast across the summit of Cinder Cone shows the double-rimmed crater at the top of the 700-foot-high volcanic cone of loose scoria. The inset photo shows an aerial view, looking to the southwest, of the cone and its surrounding lava flows and ash deposits. Many people were misled by the youthful appearance of these volcanic features into believing “eyewitness accounts” of eruptions here during the 1850's.



buried earlier cone can be seen on the larger cone's south side. Much of the earlier cone was probably destroyed by lava flows erupting from its base. Blocks of red, cemented scoria within the Painted Dunes lava flows (see geologic map) are pieces of this earlier cone, which were carried away by the flowing lava.

Beginnings of a Controversy

The eruptions and volcanic history of Cinder Cone have been an ongoing controversy for more than a century, in part because of the starkly beautiful contrast between the very new looking, unvegetated cone and lava flows and the surrounding mature forest. In the early 1870's, H.W. Harkness, a medical doctor and observant amateur scientist from San Francisco, visited and described the Cinder Cone area (Harkness, 1875). He was impressed by the apparent youthfulness of the volcanic features, and described a number of lines of

evidence that he interpreted to mean that Cinder Cone was only about 25 years old.

After presenting his findings at a meeting of the California Academy of Sciences, Harkness was contacted by Henry Chapman, an Academy member, who told him of hearing the gold prospectors tell their story. He was also contacted by several others who claimed to have witnessed a volcanic eruption in the Lassen area around 1851, including a Dr. O.M. Wozencraft. Harkness thought that all these tales of volcanic activity might be related to an eruption of Cinder Cone.

The circumstances surrounding these reports are somewhat obscure and inconsistent. Several reports of “volcanic eruptions” in the Lassen area had appeared in northern California newspapers in the 1850's, but Harkness was probably unaware of them. In the earliest of these, published in the August 21, 1850, edition of the *Daily Pacific News*, a San Fran-



This extremely young looking lava flow (Fantastic Lava Beds flow 2; see geologic map) was the last flow erupted at Cinder Cone. Its unweathered, rough surface misled early visitors into believing that it had been erupted no more than a few decades before.

cisco newspaper, an unnamed observer reported seeing an erupting volcano with "burning lava still running down the sides." In 1859, the *San Francisco Times* printed an article in which Dr. Wozencraft and a companion were purported to have seen, from a position somewhere west of the Lassen area, flames in the sky that they attributed to a volcanic eruption. This article was widely reprinted and popularized in other papers, but no specific date or location was given for their sighting. The *Shasta Republican* noted on several occasions in April 1859 that "the Dr.'s imagination is far more active than any volcano in our County or State." It was in Harkness' 1875 report that the date of Wozencraft's observation is first mentioned to be the winter of 1850–51.

Early Geologic Studies

The first geologist to study Cinder Cone was Joseph Diller (Diller, 1891, 1893), who was among the first U.S. Geological Survey (USGS) scientists to study volcanoes. Diller made careful observations of Cinder Cone and interviewed many Native Americans and European trappers and settlers who were in the Lassen region in 1850. None of them could recall witnessing any volcanic activity in the area. Diller knew that an "emigrant road" (the Nobles Trail), used by settlers coming to California in the early 1850's, passes close to the base of Cinder Cone. He spoke with several people who had "crossed the trail" in 1853. They noted that a large, solitary willow bush (*Salix scouleriana*) near the summit of Cinder Cone was "as large then as now." Today, more than a century after Diller's interviews, this bush is still alive and little changed.

Because the "Scouler willow" at the summit of Cinder Cone was already mature in 1853,

Diller concluded it was extremely unlikely that an eruption could have occurred there in the winter of 1850. He also noted that trees rooted in volcanic ash erupted from the cone were about 200 hundred years old and that the oldest trees on related lava flows were about 150 years old. Diller believed he recognized two eruptive sequences, which each produced lava flows. However, he thought that only the older eruption was explosive, creating Cinder Cone and the ash deposits. In regard to the explosive eruption, he concluded that "Whatever may be the historical testimony as to the time of the eruption, the geologic evidence clearly demonstrates that it must have occurred long before the beginning of the present century" (before 1800). Diller therefore speculated that the explosive eruption had occurred between about A.D. 1675 and 1700 and that the younger, quiet eruption was "certainly" sometime before 1840.

In the mid-1930's, USGS volcanologist R.H. Finch attempted to improve on Diller's work. On the basis of other studies done at



The first geologist to study Cinder Cone was Joseph S. Diller. He made many careful observations and correctly concluded in his 1891 report that "Whatever may be the historical testimony as to the time of the eruption, the geologic evidence clearly demonstrates that it must have occurred long before the beginning of the present century" (before 1800).

Cinder Cone, Finch thought (1) that there had been at least five separate lava-flow events, as suggested by crude, experimental magnetic measurements (Jones, 1928); (2) that the youngest lava flow was extruded in 1851, accepting Harkness' (1875) historical "evidence" and ignoring Diller's interviews and conclusions; and (3) that there had been at least two distinct explosive eruptions of the cone (Finch and Anderson, 1930). Using these assumptions and tree-ring measurements, Finch proposed a complex and detailed eruptive chronology for Cinder Cone that spanned nearly 300 years (Finch, 1937). From measurements of the rings of one particular tree, which showed two periods of slow growth, he thought that the two explosive eruptions occurred in A.D. 1567 and 1666. He also concluded that the five lava flows were extruded in 1567, 1666, 1720, 1785, and 1851.

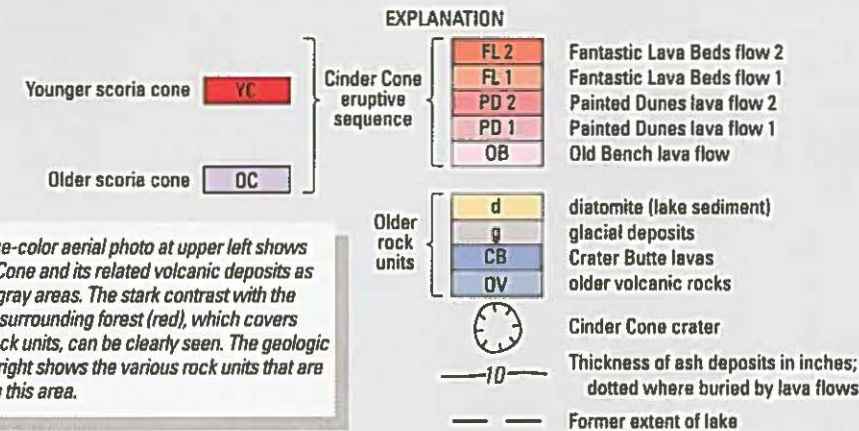
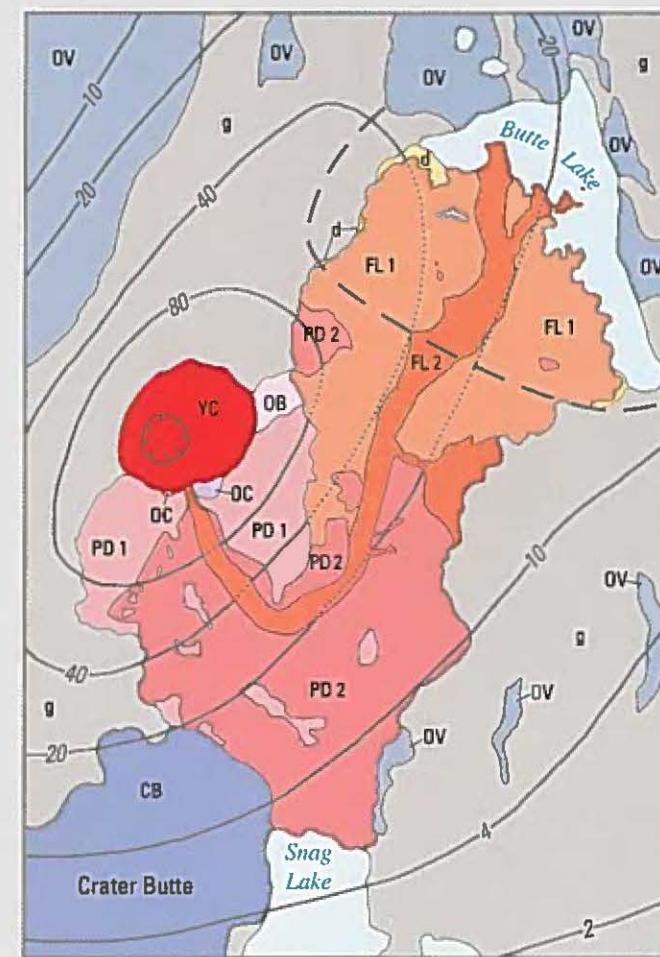
New Geologic Studies

After Finch published his work in 1937, few additional studies were done on volcano hazards in the Lassen area. However, that changed on May 18, 1980, when Mount St. Helens, Washington, exploded in one of the most devastating volcanic eruptions of the 20th century. After the eruption, the USGS began reevaluating the risks posed by other potentially active volcanoes in the Cascade Range, including those in Lassen Volcanic National Park. Since that time, USGS scientists have been working in cooperation with the National Park Service to better understand volcano hazards in the Lassen area. As part of this work, the history of Cinder Cone has been reexamined. Most of the features of Cinder Cone have changed little since Harkness first described them in the 1870's, but all of the assumptions on which Finch based his conclusions have now been shown to be incorrect.

Through new field and laboratory work and by reinterpreting data from previous studies, USGS scientists have shown that the entire eruptive sequence at Cinder Cone represents a single continuous event. During this event, the composition of the molten rock (magma) feeding the eruption changed from basaltic andesite to andesite and then back to basaltic andesite, but with a higher titanium content. Chemically, basaltic andesites are volcanic rocks containing 53 to 57% silica (SiO_2), and andesites are those containing 57 to 63% silica. Though chemically distinct, the lava flows and scorias at Cinder Cone are similar in appearance. They are dark, fine-grained rocks, containing a few visible crystals of the minerals olivine, plagioclase, and quartz.

The earlier erupted group of volcanic deposits at Cinder Cone, which are relatively titanium-poor, consist of the older scoria cone, the Old Bench flow, the two Painted Dunes lava flows, and the lower part of the widespread

INFRARED AERIAL PHOTO AND GEOLOGIC MAP OF THE CINDER CONE AREA



ash layer. The later erupted, relatively titanium-rich group consists of the large, younger scoria cone, the upper part of the ash layer, and the two Fantastic Lava Beds flows. Flow 2 of the Fantastic Lava Beds (see geologic map) is the flow that everyone but Diller thought had been erupted in 1851.

The ash on the Old Bench and Painted Dunes lava flows is brightly oxidized because it fell on the lava flows when they were still hot. This oxidized ash belongs to the same compositional group as the Fantastic Lava

Beds flows, the last flows erupted at Cinder Cone. All the volcanic materials at Cinder Cone therefore represent a single eruptive sequence that probably spanned no more than a few months.

Another line of evidence for this conclusion is the "paleomagnetic" record preserved in Cinder Cone's lava flows. As lava cools, the local orientation of the Earth's magnetic field at that time is recorded in the rock as a "remanent" magnetization. If the pattern of past variations in the orientation of the Earth's

magnetic field in a region is known, scientists can compare a remanent magnetization to that pattern and may be able to identify one or more time periods as short as a few decades in which the flow could have cooled. Because the orientation of the Earth's magnetic field in northern California during the 1850's is well known and is different from the remanent magnetizations at Cinder Cone, the lava flows there could not have been erupted in 1850 or 1851. Also, there are no discernible differences in the magnetic orientation recorded by

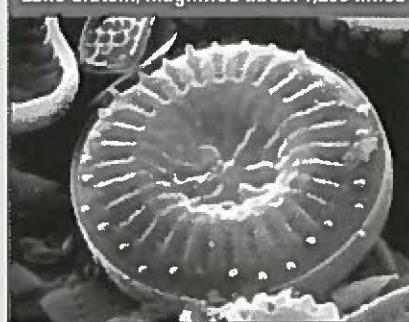
TREES AND LAKES HELP SCIENTISTS DECIPHER THE GEOLOGIC HISTORY OF CINDER CONE



This trunk of a "quaking aspen," a tree that grows in wet ground near lakes or streams, was toppled and partly buried by flow 1 of the Fantastic Lava Beds. A wood sample from this tree provided a radiocarbon age that helped U.S. Geological Survey scientists confirm that the eruption of Cinder Cone occurred between A.D. 1630 and 1670. Additional radiocarbon ages that are consistent with this age were obtained from drowned trees in Snag Lake (see geologic map). This lake formed when the Painted Dunes lava flows blocked Grassy Creek, a stream draining the central plateau of Lassen Volcanic National Park.

Water from Snag Lake seeps beneath the Cinder Cone lava flows to supply Butte Lake, 2 miles to the north. Butte Lake is a remnant of a larger lake that was partly filled by lava flows during the eruption of Cinder Cone. A distinctive type of sediment, called diatomite, found along the margins of the Fantastic Lava Beds flows helps to indicate the former extent of that larger lake, as does the quaking aspen, which grew near the lake's edge. The diatomite was

Lake diatom, magnified about 1,200 times



created by the accumulation on the lake bottom of diatoms, microscopic single-celled plants whose skeletons are made of opaline silica. When advancing lava flows entered the lake, they squeezed up some of the diatomite along their margins (see geologic map). Diatoms can provide information on the ages and environments of ancient freshwater and marine deposits.

any of the Cinder Cone lava flows, and so the flows had to be extruded during an interval of less than 50 years.

Although paleomagnetic evidence can be used to rule out the 1850's as the age of Cinder Cone, it does not provide an actual age for its eruption. By measuring levels of carbon-14 in samples of wood from trees killed by the

eruption of Cinder Cone, USGS scientists obtained a "radiocarbon" date for the eruption of between A.D. 1630 and 1670. Such a date is also consistent with the remanent magnetization preserved in the lava flows.

The series of eruptions that produced the volcanic deposits at Cinder Cone were complex and are by no means completely understood. However, the new studies done by USGS scientists refute the purported accounts of an eruption in the early 1850's and confirm Diller's (1891, 1893) interpretation that Cinder Cone erupted in the latter half of the 17th century. They also suggest that the 1666 tree-ring date proposed by Finch (1937) for his "second" explosive eruption at Cinder Cone might actually date the entire eruptive sequence.

This recent work of USGS scientists at Cinder Cone, in cooperation with the NPS, is helping to provide a better understanding of volcano hazards in the Lassen Volcanic National Park area. The work of these scientists is only part of the USGS Volcano Hazards Program's ongoing efforts to protect people's lives and property in all of the volcanic re-

gions of the United States, including the Pacific Northwest, eastern California, Wyoming, Alaska, and Hawaii.

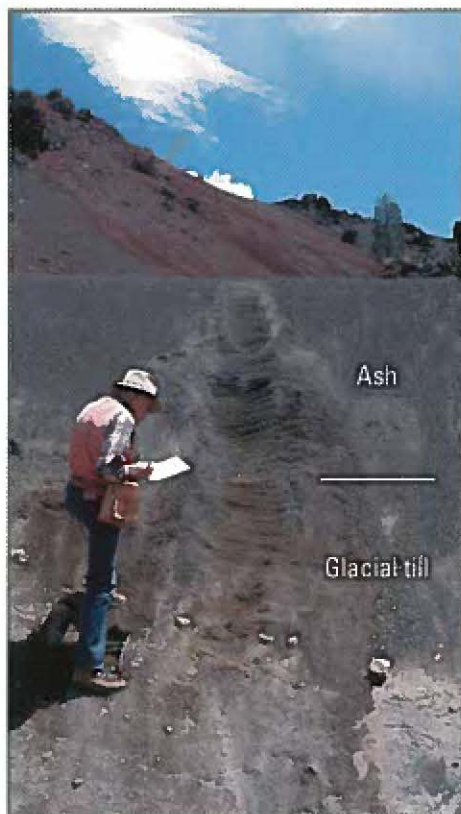
Michael A. Clynn, Duane E. Champion, Deborah A. Trimble, James W. Hendley II, and Peter H. Stauffer

Graphic design by
Sara Boore and Susan Mayfield
Banner design by Bobbie Myers

COOPERATING ORGANIZATIONS
Lassen Park Foundation
National Park Service
U.S. Forest Service

REFERENCES

- Diller, J.S., 1891, A late volcanic eruption in northern California and its peculiar lava: U.S. Geological Survey Bulletin 79, 33 p.
- Diller, J.S., 1893, Our youngest volcano: National Geographic Magazine, v. 4, p.93-96.
- Finch, R.H., 1937, A tree ring calendar for dating volcanic events at Cinder Cone, Lassen Volcanic National Park, California: American Journal of Science, v. 33, p.140-146.
- Finch, R.H., and Anderson, C.A., 1930, The quartz basalt eruptions of Cinder Cone, Lassen Volcanic National Park, California: University of California Publications in the Geological Sciences, v. 19, p. 245-273.
- Harkness, H.W., 1875, A recent volcano in Plumas County: California Academy of Sciences Proceedings, v. 5, p.408-412.
- Jones, A.E., 1928, Magnetism of Cinder Cone lava flows, Lassen Volcanic National Park, California. Hawaiian Volcano Observatory Bulletin, v. 16, p. 61-65.



Cinder Cone has a related, widespread ash deposit, seen here being examined by a U.S. Geological Survey scientist, which is identifiable for 8 to 10 miles from the cone. On the Old Bench and Painted Dunes lava flows, this ash is brightly oxidized because it fell on the lava flows when they were still hot. Because the oxidized ash has the same composition as the last lava flows erupted at Cinder Cone (the Fantastic Lava Beds flows), Cinder Cone must have formed in a single eruptive sequence that probably spanned no more than a few months.

For more information contact:
Lassen Volcanic National Park
P.O. Box 100, Mineral, CA 96063
(530) 595-4444
<http://www.nps.gov/lavo/>
or

<http://volcanoes.usgs.gov/>
See also *Volcano Hazards of the Lassen Volcanic National Park Area, California* (USGS Fact Sheet 022-00) and *Eruptions of Lassen Peak, California, 1914 to 1917* (USGS Fact Sheet 173-98).

☆ U.S. Government Printing Office: 2000-584-118