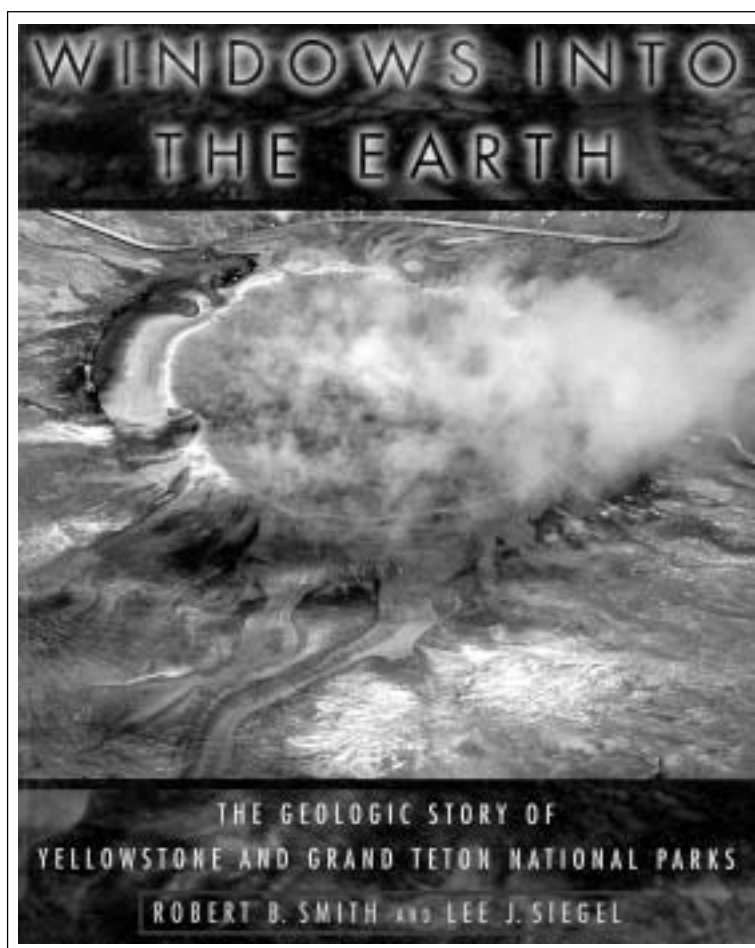


Windows into the Earth:

The Geologic Story of Yellowstone and Grand Teton National Parks

by Robert B. Smith and Lee J. Siegel

Book review by
Mike Thompson



Oxford University Press, Inc., New York, 2000, 242 pages, \$29.⁹⁵

Recently, while instructing beginning students in chemistry in the Geology Room at the Portland Community College, Sylvania, campus, I noticed that the geology instructor had numerous articles pertaining to hot spots, volcanism, and Yellowstone pinned to the wall. Having worked on the collection, analysis, and interpretation of Yellowstone's thermal fluids for over 20 years, I inquired about the possibility of teaching a summer session class on Yellowstone. I envisioned a two-week lecture class followed by a two-week field trip. It was an easy sell to the geology instructor. But I needed a textbook.

Almost simultaneously, I received a request from *Yellowstone Science* to review Smith and Siegel's new book, *Windows into the Earth*. I am familiar with some of Smith's work in and about the

park. He was instrumental in setting up portable seismometers throughout Yellowstone's backcountry regions and had instigated the resurveying of the park's elevation benchmarks in 1984. This led to the discovery that the park had been uplifted about three feet since 1927. This result was so unexpected that the initial reference marker had to be changed because the uplift was so pervasive that almost the entire park was affected. Smith is an important, knowledgeable, and influential Yellowstone research scientist.

I had heard rumors sometime ago that Smith was writing a book on Yellowstone, and I expected a monograph on Yellowstone and Smith's science in the park. Fortunately for all those who dearly love Yellowstone, *Windows into the Earth* is **not** such a book. This book is valuable to all, from the curious park visitor to the experienced park researcher. It is well written and easy to read, understand, and

appreciate.

In the first chapter, the authors begin with the Hebgen Lake earthquake of 1959. After discussing some survivor stories of the quake, they quickly move on to the geologic events of that night of terror: ruptures along the Hebgen and Red Canyon faults, the large vertical displacements (scarps) that occurred, the huge Madison Canyon landslide that dammed the river to make Quake Lake, and other events occurring that night. The authors also discuss the effects inside Yellowstone National Park, both to visitors, roads, and facilities and to subterranean paths of water flow for geysers and hot springs—both active and dormant—that reacted immediately to the earthquake stimuli. After reading over the references, I am somewhat surprised that the authors did not cite U.S. Geological Survey Professional Paper 435¹ on the Hebgen Lake earthquake. I am perplexed about why this important resource was overlooked.

In the second chapter, the authors discuss both oceanic and continental hot spots. Importantly, they describe how the Yellowstone hot spot originated, migrated, and differs from the more typical oceanic hot spot. Also detailed are other hot spots of the solar system, showing that hot spots are not limited to Earth. I especially enjoyed the discussions pertaining to the origin of the Yellowstone hot spot, whether or not the Columbia River basalts are part of it, and the track of the hot spot over time.

Chapter three concerns the three calderas that formed in the Yellowstone region. The emphasis is placed on the third, most recent caldera, created approximately 630 million years ago. Included in this chapter are discussions and diagrams about caldera collapse as the eruptions proceeded. Additionally, the authors discuss post-caldera eruptions—resurgent domes and lava flows inside the caldera. They end with a description of steam and water explosions (hydrothermal eruptions) and examples of such features.

If chapter three is concerned with caldera formation and eruptions, then chapter four is about heat flow and the two major mechanisms for transferring heat from rock to water and how it is eventually released at the surface in the form of fumaroles, geysers, and hot springs. In other words, this chapter is about the thermal features of Yellowstone. The authors briefly describe what makes fumaroles, acidic hot springs and mud pots, and neutral hot springs and geysers. The subsurface plumbing for such systems is also explained as it was inferred from previous borehole investigations in the park.

This is one chapter with which I have some concerns, the first of which is relatively minor. To my knowledge, the deepest borehole in the park is the 1,081-foot deep “Y-12” at Norris Geyser Basin;² it is not “almost 1,500 feet,” as the authors state at the top of page 68. The other pertains to recharge of the hydrothermal system. Isotopic measurements of deuterium, oxygen-18, and tritium all indicate that the deeper hydrothermal water is isotopically “lighter” than surrounding meteoric water and is depleted in tri-

tium.³ This has been interpreted by Fournier and others (op. cit.) to mean that the source of the deep water is higher than the present elevation of the thermal basins and must be older than the atmospheric nuclear testing that occurred in the mid-twentieth century. Smith and Siegel, page 73, imply that rain and snowmelt are the source of the thermal water.

Chapter five discusses the spectacular rise of the Teton Range and the geologic development of Jackson Hole. Of course, the Teton region is dependent on the 13 million-year-old Teton fault. The authors discuss the historical progress of this fault and present evidence that it may be more than 30 million years old. This whole region is being influenced by the thinning and stretching of the Basin and Range Province, which gives rise to the north-south trending faults, valleys, and mountains.

Chapter six discusses the effects of glaciations on the entire region. The Yellowstone region, sitting higher than the Teton region, apparently was the source of large regional glaciers; however, they were not part of the continental glaciers further north. These large glaciers arose and flowed south from Yellowstone, filling Jackson Hole with glacial debris. Numerous alpine glaciers in the Teton Range also transported more glacial debris into the valley. Such debris created the abundant moraines which formed lakes along the west side of Jackson Hole. These glaciers also cut the U-shaped valleys that allow access into the Teton Range. Not only did the glaciers cut the U-shaped valleys of both Yellowstone and Grand Teton national parks, but in Jackson Hole the glacial debris may also have filled the valley some 10,000 or more feet. The retreating glaciers also left terminal and lateral moraines which influenced the valley’s topography, hydrology, pond and lake development, and drainage of streams and rivers.

It’s interesting to note that although these large glaciers originated in Yellowstone, the Grand Canyon of the Yellowstone was neither affected nor sculpted by ice; rather, it was just filled with ice. That the canyon filled with ice during the last glaciations is evident from the glacial erratic boulder at the head of the Seven

Mile Hole trail. As the glaciers retreated and melted, the melt water increased the flow of the Yellowstone River and, consequently, the rate of erosions of the hydrothermally altered canyon. (The altered material erodes more easily than volcanic rock.) This erosion continues today. But the area was glaciated; the large U-shaped valleys of the Yellowstone River below the Grand Canyon of the Yellowstone bear evidence of that.

Chapter seven pertains to possible future earthquake and volcanic events. The hazards of a fourth, caldera-forming volcanic eruption seem remote for now. Because the interval between the first and second was 0.7 million years and the interval between the second and third is currently 0.63 million years, it may be another 0.1 million years before the next eruption. However, “smaller” eruptions are harder to predict. For comparison, the tremendous volcanic explosion that created the Crater Lake, Oregon, caldera was just slightly larger than the one that created the West Thumb caldera. Yet the West Thumb caldera is a “smaller” eruption. For earthquakes, the situation is different. Based on average recurrence intervals, the Teton fault is overdue for a significant tremor. As the authors indicate, trying to determine the probability of such events is difficult at best. Using the geologic record to ascertain the frequency of such events may be misleading, especially if the events were clustered in the past. In trying to predict significant earthquakes, I am reminded of the Parkfield experiment along the San Andreas fault. Based on recurrence intervals, an earthquake having a magnitude of about 6 was predicted to occur there between 1987 and 1992. However, as of the year 2000 such an earthquake has not occurred—but it will. Earthquake predictions are a qualitative, not a quantitative science.

The last two chapters describe geologic tours through both parks. In chapter eight, the authors suggest beginning the tour at Jackson, Wyoming. The tour proceeds north into Grand Teton National Park and loops west to Jenny Lake. I was impressed by the authors’ selection of viewpoints, usually off the heavily traveled highway. The photos from some of



*The northwest rim of the Yellowstone caldera north of Madison Junction. The steep south-facing rim formed when the caldera floor (foreground) sank downward during the most recent giant eruption 630,000 years ago. Mount Holmes, a 10,336-foot peak (background), is part of the Gallatin Range, the southern end of which was destroyed by Yellowstone's first caldera-forming eruption two million years ago. From *Windows into the Earth: The Geologic Story of Yellowstone and Grand Teton National Parks*, by Robert B. Smith and Lee. J. Siegel.*

them are simply spectacular. They also conveniently note optional stops and viewpoints between major stops on the tour.

The Madison River canyon slide of 1959 was not the only deadly slide in the Yellowstone region. Another even larger landslide happened in Gros Ventre Canyon in 1925. The stop overlooking the Gros Ventre slide—where the mountain slid and built a natural dam of the Gros Ventre River, which subsequently failed and flooded the town of Kelly, killing six people—made me wonder why the authors did not focus more on the fact that landslides are potential hazards in the region. According to the authors, the earthquakes that caused the Gros Ventre slide were a series of small, insignificant tremors, not a single-event major earthquake such as happened in the Madison River Canyon. Also, it would have been helpful if the pronunciation of “Gros Ventre” were placed earlier in the book.

Continuing north from Grand Teton National Park into Yellowstone National Park brings one to the South Entrance and the beginning of chapter nine. The first stop, at West Thumb Geyser Basin, is located at the intersection of the South Entrance Road and Grand Loop Road. From West Thumb Geyser Basin the tour proceeds west to the Upper Geyser Basin (Old Faithful), Midway and Lower geyser basins, and Firehole Canyon loop road before continuing on to West Yellowstone, Montana, where the first day's tour ends. Depending on time of arrival

in West Yellowstone, one can continue with the optional tour to the Hebgen Lake fault viewpoints, start with them at the beginning of the next day, or skip them entirely. Whether or not the Hebgen Lake fault is visited, the Yellowstone tour continues by traveling to Norris Geyser Basin, from there north to Mammoth Hot Springs, east towards Tower Junction and Tower Falls, then south over Dunraven Pass to Canyon and on to Fishing Bridge, and finally east to Lake Butte to end the tour.

At the beginning of this review, I related how I was attempting to “sell” a Yellowstone field class. This book provides me and any other Yellowstone field instructor with a perfect geologic text that includes not only important references but also Internet resources. I have no hesitation recommending this book to all serious Yellowstone researchers and to any park visitors interested in learning about the geology of Yellowstone and Grand Teton national parks. The language is somewhat technical, but the authors write clearly and define geologic terms. They carefully guide the reader through the geologic processes of hotspot volcanism, basin and range geology, Yellowstone volcanism, and massive regional glaciations. They also assess future earthquake, volcanic, and other geologic hazards. Each chapter can stand alone so that one can either jump all over the book, reading only the most pertinent parts, or read it straight through. This book is a treasure. Get it! 🍷

Mike Thompson is currently an instructor of chemistry at Portland Community College and an adjunct instructor of organic chemistry at Warner Pacific College, both located in Portland, Oregon. He previously was a chemist for the USGS before retiring in 1995. He worked closely with R. O. Fournier and R. A. Hutchinson collecting and analyzing thermal fluids from all the various hot springs and geyser basins, both major and minor, in Yellowstone National Park. He has also authored or co-authored numerous research reports on the chemistry and interpretation of the park's thermal waters.

NOTES

- ¹ U.S. Geological Survey. 1964. *The Hebgen Lake, Montana, earthquake of August 17, 1959: U.S. Geological Survey Professional Paper 435*. U.S. Government Printing Office.
- ² White, D.E., R.O. Fournier, L.J.P. Muffler, and A.H. Truesdell. 1975. *Physical results of research drilling in thermal areas of Yellowstone National Park, Wyoming: U.S. Geological Survey Professional Paper 892, 54–57*. U.S. Government Printing Office.
- ³ Fournier, R. O., R.L. Christiansen, R.A. Hutchinson, and K.L. Pierce. 1994. *Yellowstone National Park field trip: Volcanic, hydrothermal, and glacial activity in the Yellowstone region: U.S. Geological Survey Bulletin 2099, 4*. U.S. Government Printing Office.