Exploring the Highest Sierra

James G. Moore
Stanford, California: Stanford University Press

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IN HIS PREFACE to Exploring the Highest Sierra, the author James Moore reflects on his first youthful encounter with California’s Sierra Nevada. It was a week-long backpacking trip taken with his brother George in the summer of 1947. The impressions of that outing on the teenage Moore gave rise to an eminent career in geology (chiefly with the U.S. Geological Survey) whose major focus was to become the Sequoia and Kings Canyon region. Along with Paul Bateman, Moore has assembled much of the geology of the Sierra Nevada, and this book is the culmination of a lifetime of exploration, fieldwork, and science culled from these mountains. Relying on much of his own research, Moore’s book engages us in a more or less personalized survey of the history and geology of the southern Sierras. The result is a commanding, self-assured, jargon-free, and thoroughly impressive work. After reading this book, one cannot help but sense that after more than 50 years since that first encounter, the Sierras still doggedly grasp Moore’s imagination.

Moore sets himself the task of giving the reader a broad geologic sweep while allowing for excursions into deeper aspects of scientific geology. The organization of the book is quite straightforward, reflecting the major elements of the geologic discipline: rocks, structures, and processes. But because geology is so closely associated with exploration and mapping, Moore has chosen to devote nearly half the book to marvelous portrayals of the early expeditions and topographic surveys of the Sierra Nevada. He obviously considers human history an important aspect in the evolution of our understanding of the physical nature of the Sierra Nevada. The historic chronology depicts Sierra explorations, from Jedediah Smith’s first attempt to cross the southern Sierras and John C.
Fremont’s initial probes across Walker Pass, to the statewide geological investigations of William P. Blake of the Williamson railroad survey of 1853—a survey that produced the first geologic map of California in 1858. There is also a brief account of the reconnaissance exploration of the Sierra high country by the California Geological Survey, the forerunner of the Division of Mines and Geology. It was the idea of the CGS’s first director, Josiah Whitney, to conduct a geological survey for the state.

Many scientific questions and debates were spawned from these initial geologic surveys. One of the earlier skirmishes concerned the issue of the molten versus metamorphic origin of granites—a debate that took nearly half a century to resolve. Other early geological controversies involved the conflict between Whitney and John Muir over whether Yosemite Valley was formed by glaciers (Muir’s theory) or had its origins in faulting and subsidence (Whitney). Moore depicts the role of early scientific survey instruments that figured prominently in the methodical struggle to accurately describe the mountains. It was one such primitive instrument that led Clarence King to erroneously report Mt. Whitney’s elevation as 15,000 feet.

The nascent era of terra incognita ended with the first comprehensive mapping surveys conducted by the United States Geological Survey. The results were the publication of six 30-minute quadrangles (1:125,000). Up to this time, only Joseph LeConte’s less-detailed map of 1896 provided the basis for understanding the Sierra’s complex physical landscape. It wasn’t until the 1950s that the need for more detailed maps featuring recreational trails led to the production of 15-minute quadrangle maps (1:62,500), constructed using aerial photography technology. Later, the U.S.G.S. completed detailed mapping of the Sierra at 7.5 minutes (1:24,000). These topographic quadrangles provided the level of detail necessary for precise geologic mapping. Beginning in 1965, Moore authored or coauthored 15 geology maps covering the Sierra Nevada. Geologic mapping in such rugged terrain is a difficult venture, but for someone like Moore it gave rise to a level of understanding that only a prolonged, detailed geologic mapping endeavor can provide.

Reconstructing the geologic history of any region is a perplexing undertaking, akin to piecing together a giant jigsaw puzzle with
missing and shredded pieces. You have to grasp the fine details while trying to visualize the whole picture. It is a venture of scope and scale, and the geology of the Sierra Nevada provides a great challenge and opportunity to understand how the details fit into the whole. Moore’s book demonstrates, for example, such classic enigmas as the problematic age and origins of the terranes of metamorphic rocks within the Sierran complex. Remnants of these metamorphic roof pendants are thought to be associated with complex subduction along a plate boundary during or near the end of the Jurassic. They appear to be from tropical oceanic crust that “docked” along a broad area of western North America. The displacement of these older rocks began during the Cretaceous with the emplacement of the Sierra Nevada batholith, which formed and cooled at depth (13km). From age-dating methods and sampling, the Sierra plutons appear to have formed from west to east over a period of 30 million years. Employing some of his own pioneering work, Moore discusses the “quartz diorite line” that separates western zones of tonalite from areas dominated by granodiorite and granite throughout the Sierra Nevada complex. Much of our insight into these events and processes derive from compositional analysis of granitic rocks. Moore explains that from many experimental methods, processes, and procedures, such as determining specific gravity and chemical composition of Sierra granites, geologic history can be tenuously reconstructed. Moore integrates these substantial “pieces” of research into the grand paradigm of plate tectonics. The result is a comprehensive, if still blurred, understanding of Sierran geologic history.

In the latter chapters, Moore heads off into discussions that focus on topics related to geologic processes such as mineral deposits, volcanism, glaciation, landslides, and geologic structures. Although the western foothill gold deposits are associated with remnant outcrops of Paleozoic and Mesozoic metamorphic rocks, he explains that because of the lack of widespread metamorphic belts, few substantial mineral deposits are found in the southern Sierra Nevada regions. During the Cenozoic, the southern Sierras experienced three phases of modest volcanic activity that produced either scattered deposits of rhyolite and dacite material during the initial phase, or
later, deposition of basaltic lavas, mostly along the east escarpment of the Owens Valley.

John Muir’s curiosities about the effect of glaciation on the formation of valleys in the Sierras led to discoveries of small, high-altitude glaciers. Although, as Moore points out, “there is no doubt that water has been more important than ice in the overall erosion of the Sierra Nevada,” the Pleistocene Ice Age has had a significant impact on their geomorphology (p. 288). He notes that over half of the Sequoia-Kings Canyon region was covered with ice. The Tioga Glaciation of 20,000 to 15,000 years ago shows a pattern of higher-altitude glaciation to the south and lower altitudes to the north, with the eastern flank having significantly higher glacier altitudes than the west. Because the Sierra Nevada is composed mostly of hard, crystalline rock with few young (Cenozoic) faults, landslides are uncommon compared to the Coast Ranges. The general lack of landsliding, however, has not prevented some remarkable slides from altering the Sierra landscape. Especially noteworthy is the evidence of prehistoric landslides along the gorge of the Middle Fork of the Kaweah River.

In a final chapter, Moore summarizes recent studies of the structural characteristics of the Sierra Nevada. The surprising problem facing the structural geologist is that with no crustal root holding up the highest Sierra, what does? The answer, it is believed, rests with the low-density (high silica) granitic composition of the crustal rocks in combination with the lithospheric nature of the southern Sierra Nevada substructure. Beneath the Sierra, Moore reports, is a “rib of hot, low-density asthenospheric material [that] can account for both the uplift and the westward tilt of the mountain block” (p. 321). Recent evidence suggests that this asthenospheric rib has welled up into the lithosphere and supplies the support for the mountains.

The 85-million-year-old geologic history of the Sierra Nevada reviewed in this book has been a subject of serious attention for only 150 years. As Moore reflects, for most of that brief time, the nature of our understanding of the Sierra Nevada has been generally stimulated by commerce or greed. The scale of our knowledge has also been refined by the systematic trend toward more detail. It has been
carried out by men who explored for adventure and knowledge, educated men with literary skills. They were motivated to discover something new, and were supported by government agencies and allowed to publish their findings. Our knowledge of the Sierra Nevada rests, in other words, on the adventurous scientific efforts of admirable men like James Moore.