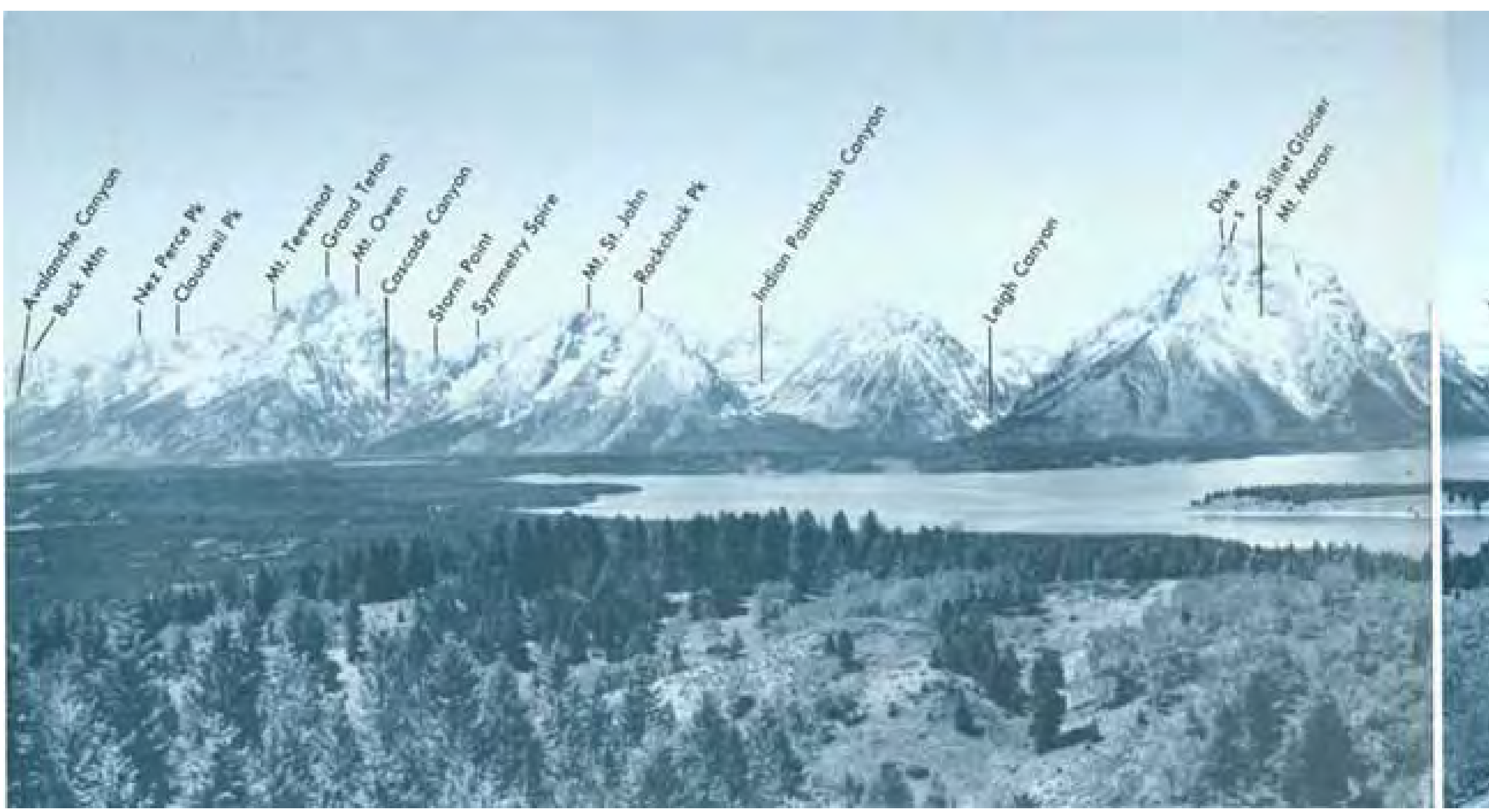
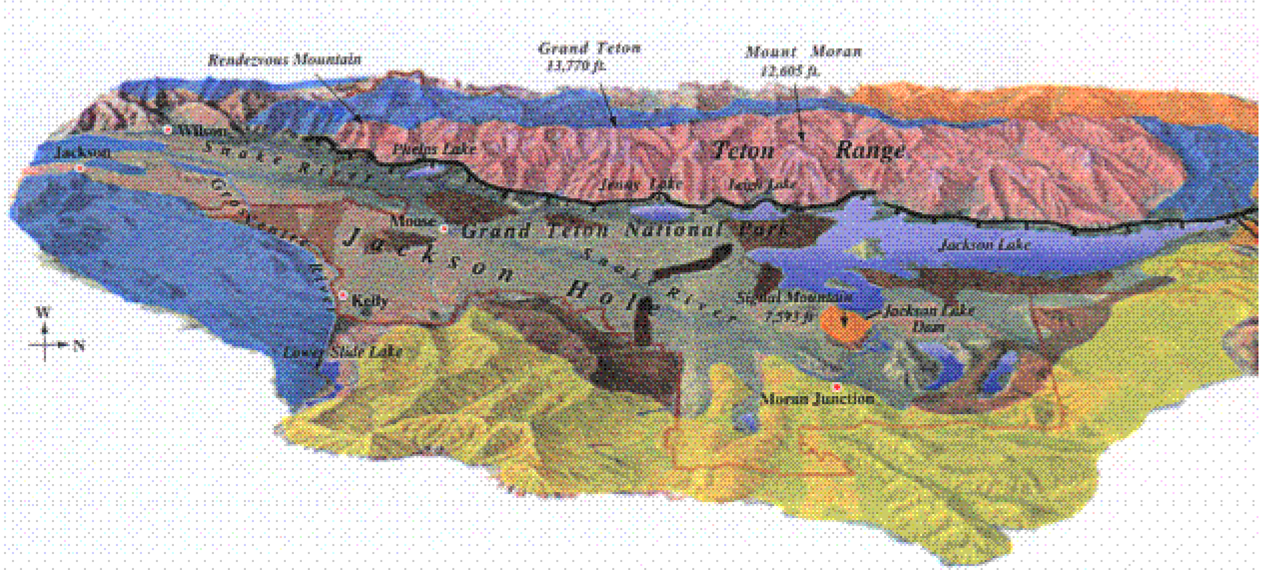
GRAND TETON GUIDE no. 7

AN AMATEUR'S REVIEW OF BACKPACKING TOPICS
FOR THE
2008
T254 EXPEDITION TO GRAND TETONS / YELLOWSTONE

GRAND TETON GEOLOGY

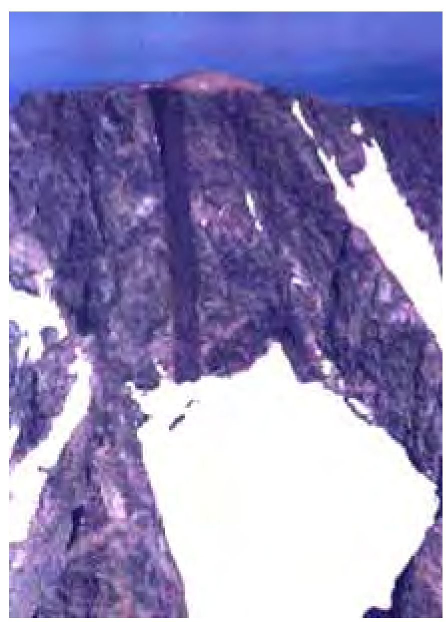
The Teton Range is the center point of the park, rising more than 7,000 feet above the floor of Jackson's Hole which borders the mountain range to the east. The steep eastern front of the range is unique in the Rocky Mountains and similar to the steep eastern front of the Sierra Nevada. It is the result of rapid uplift along the Teton fault and subsequent episodes of glacial erosion. The summit of Grand Teton at 13,770 feet is the second highest mountain in Wyoming.





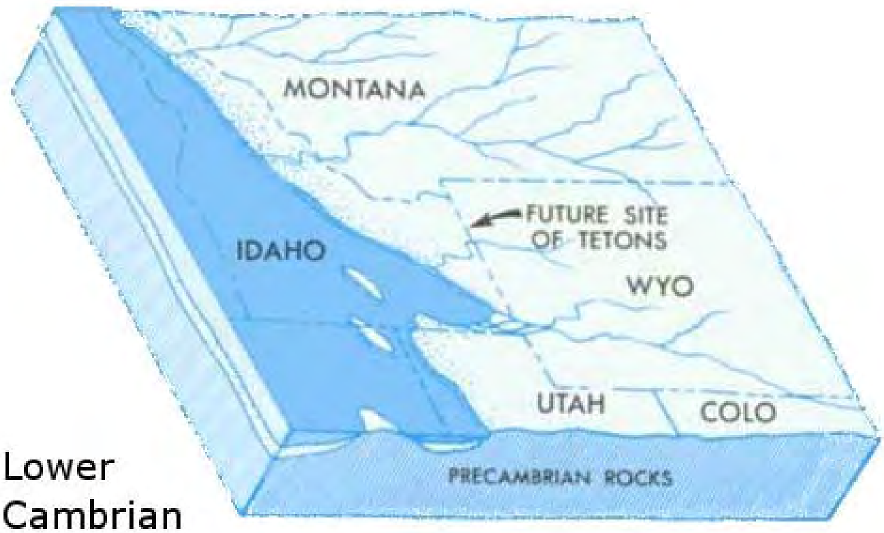
Legend

- 2.8 and 1.5 billion year old crystalline basement: granitic and metamorphic rocks.
- 540 to 245 million year old rocks primarily deposited in a deep ocean: limestone, sandstone, shale and dolomite.
- 245 to 66 million year old rocks deposited mainly in a shallow ocean: siltstone, limestone, sandstone, gypsum, conglomerates, coal beds and shale.
- 60 million to 3 million year old volcanic conglomerates, tuff, clay stone, sandstone deposited in shallow lakes accompanied by local volcanism.
- 2 million year old rhyolite and welded tuff deposited during Yellowstone's first giant, caldera-forming volcanic eruption.
- 150,000 to 14,000 year old glacial outwash and till deposited by glaciers.
- 1.6 million year old to present, landslide and stream deposits, gravel, sand and alluvium.



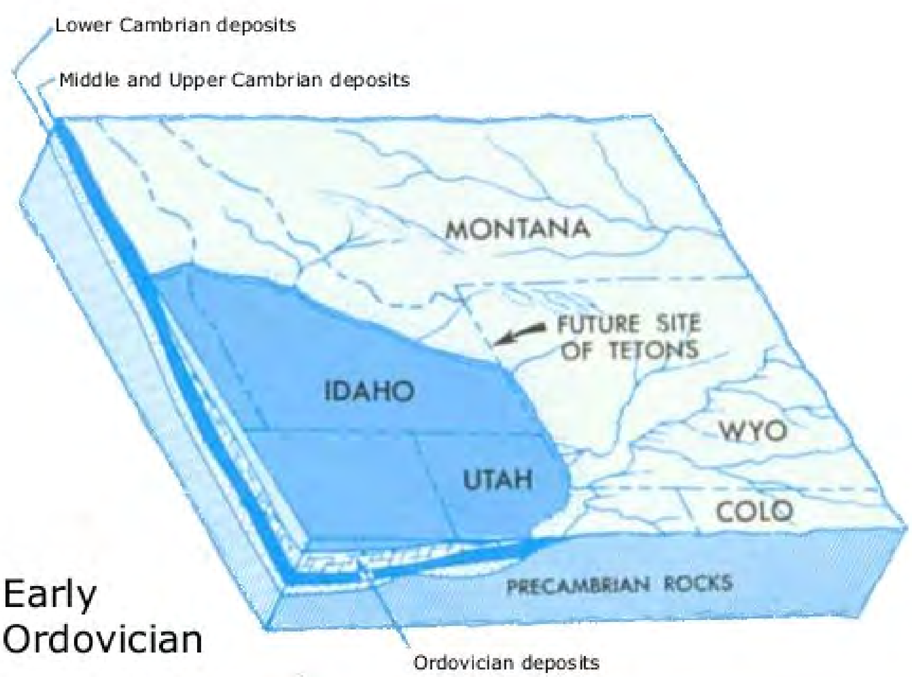
The image above is a highly generalized geologic map (after Smith and Siegel,2000). The oldest rocks in the Teton Range are 2.8 Ga gneisses and schists and 2.4 Ga granite. These were subsequently intruded by dark-colored diabase dikes around 1.1-1.3 Ga. The best known locality where this relationship can be seen is the oft-photographed Mt.Moran, shown to the right. The crosscutting diabase dike is the dark, almost black rock. The sliver of light brown colored rock at the summit of Mt. Moran is 560 Ma Flathead Sandstone.

The Precambrian basement rocks are overlain unconformably by Paleozoic sedimentary rocks. These rocks are exposed on the gentle west slope of the Teton Range forming "The Wall", a massive sequence of stratified rocks that can be seen looking westward from the floor of Jackson's Hole . Most of the sedimentary rocks were deposited in shallow marine seas during a sequence of transgressions and regressions from the Cambrian through Mississippian.Younger Paleozoic and Mesozoic rocks were probably deposited in the Teton region but subsequently removed by erosion from the western slope of the Tetons, a consequence of uplift along the Teton Fault. These younger rocks can be seen in the Gros Ventre Mountains to the east of the Grand Tetons.



Lower Cambrian

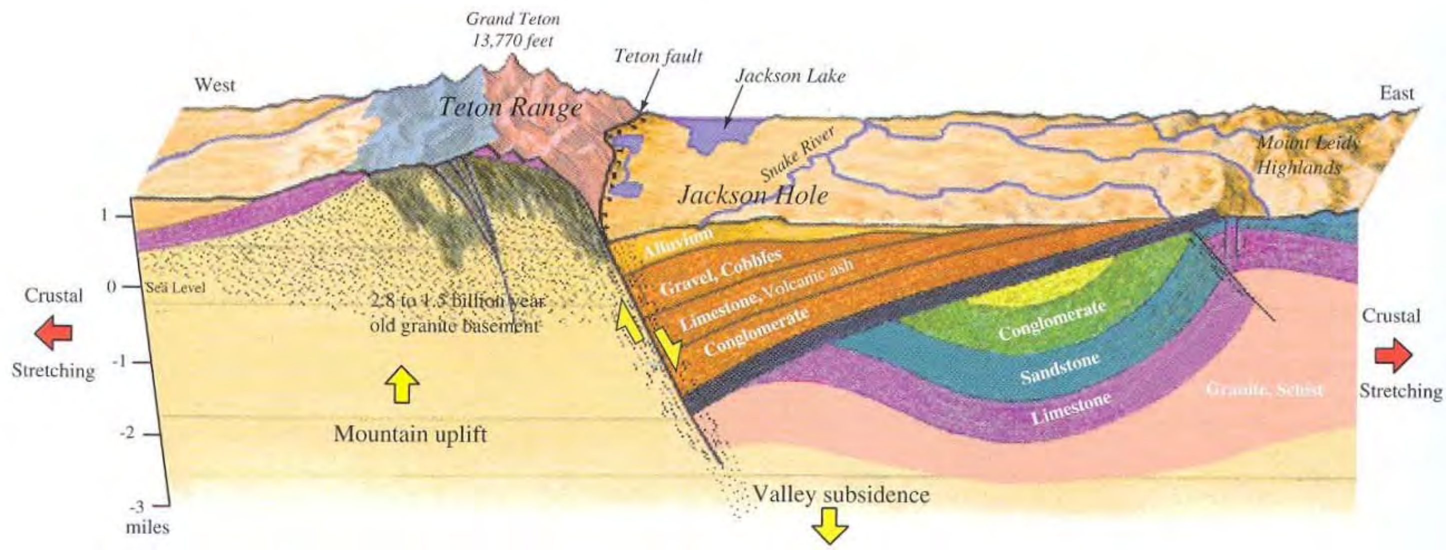
Late Cambrian



Early Ordovician

Cenozoic volcanic rocks are present in the Absaroka Range southeast of the Park and at the north and south ends of the Teton Range. Absaroka volcanics are a series of 50 Ma dacite, latites and rhyolites probably emplaced as a consequence of subduction of the Farallon Plate to the west. Nine million year old volcanics occur at the very south end of the Teton Range and in the Gros Ventre Buttes near the town of Jackson. Little is known about the genesis of these rocks. The four million year old Conant Creek tuff and two million year old Huckleberry Ridge tuff rest unconformably on Paleozoic rocks at the north end of the Teton Range. Both units represent welded tuff sequences emplaced during caldera eruptions related to the proto Yellowstone hot spot.

As the west was squeezed during the Larimide Orogeny there was extensive thrust faulting and broad folding in a wide band running north-south along the Wyomong-Idaho border, an area known today as the Wyoming Overthrust Belt. The east-west compression caused a broad upward arching of western Wyoming. Subsequent structural uplift related to plate subduction (see above) occurred about 50 million years ago producing an ancestral Teton Range during Paleocene time. The modern Teton Range, however, is quite young and is the product of uplift along the Teton Fault which began 13 million years ago. The Teton Fault, which parallels the eastern front of the Teton Range from north to south for a distance of 40 miles, is an eastward-dipping fracture in the earth's crust along which movement has occurred (see figure below). The block on the western side of the fault was uplifted, while the block on the eastern side of the fault moved downward, i.e. normal faulting. The Teton fault clearly predates arrival of the Yellowstone hot spot and its north-south strike is coincidence with other Basin and Range faults throughout the Great Basin suggesting little or no relationship to the Yellowstone hot spot.



5.3 ~ Cross section showing the fault-caused westward tilt of rocks on the west side of the Teton Range and beneath Jackson Hole. Total movement on the Teton fault and from earlier mountain-building is about 6 miles, which is the elevation difference between rock layers high in the mountains and their projected location beneath Jackson Hole.

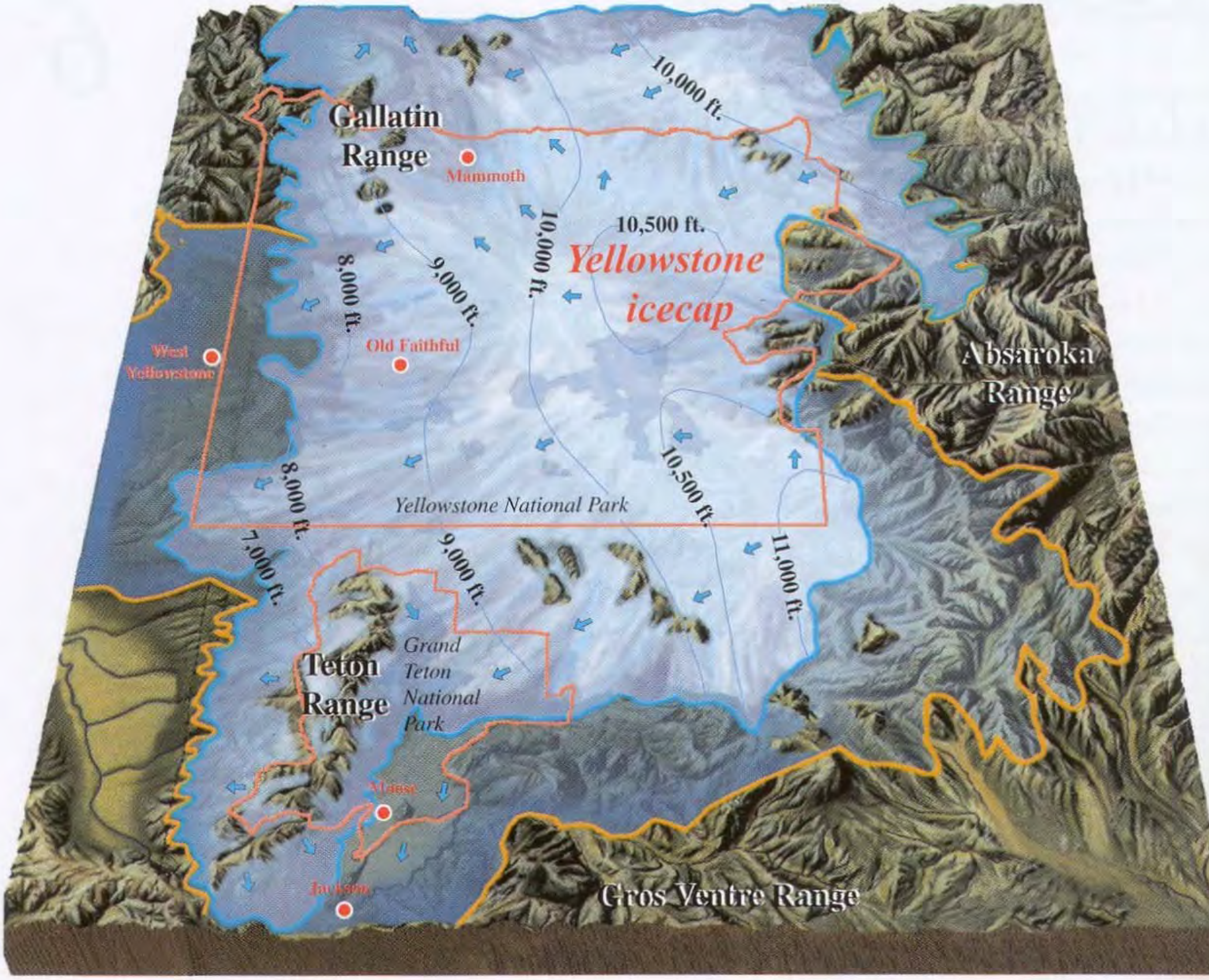
The amount of uplift, or structural relief, has been determined by comparing the elevation of a recognizable horizon on opposite sides of the fault. The Precambrian-Cambrian unconformity atop Mt. Moran is at an elevation of about 12,500 feet, while the same contact has been determined seismically to lie 23,000 beneath the surface of Jackson's Hole. The amount of structural relief this is on the order of 35,000 feet, which indicates a rate of uplift of 3 inches per hundred years! There is some uncertainty in this number, however. The Teton Fault is presently active (last eruption 4000-7000 BP), but attempts to calculate recurrence intervals generate rates from 680 to 900 to 3400 to 4000 years depending on location along the fault and stratigraphic markers utilized. This suggests that either different portions of the fault move at different rates or that seismicity has varied dramatically with time. If the latter is true, then both recurrence rates and estimates of the amount of offset per hundred years are probably now more than crude ballpark guesses.

The story of the Grand Tetons is as much a story of glaciation as it is structural geology. The present Teton landscape was developed on the uplifted Teton block by alpine glaciation along deeply incised stream valleys. Several cycles of global cooling followed by warming over the past 2 million years resulted in the advance and retreat of alpine glaciers in the Teton Range. Modern glaciers in the park are the remnants of this ice age. Glaciers such as Falling Ice Glacier on Mt. Moran and the Teton Glacier lie in cirque basins (figure to the left) at the head of alpine valleys. Strictly speaking, they are not remnants of the Pleistocene ice sheets, but rather formed during the so-called "Little Ice Age as recently as 5,000 years ago.

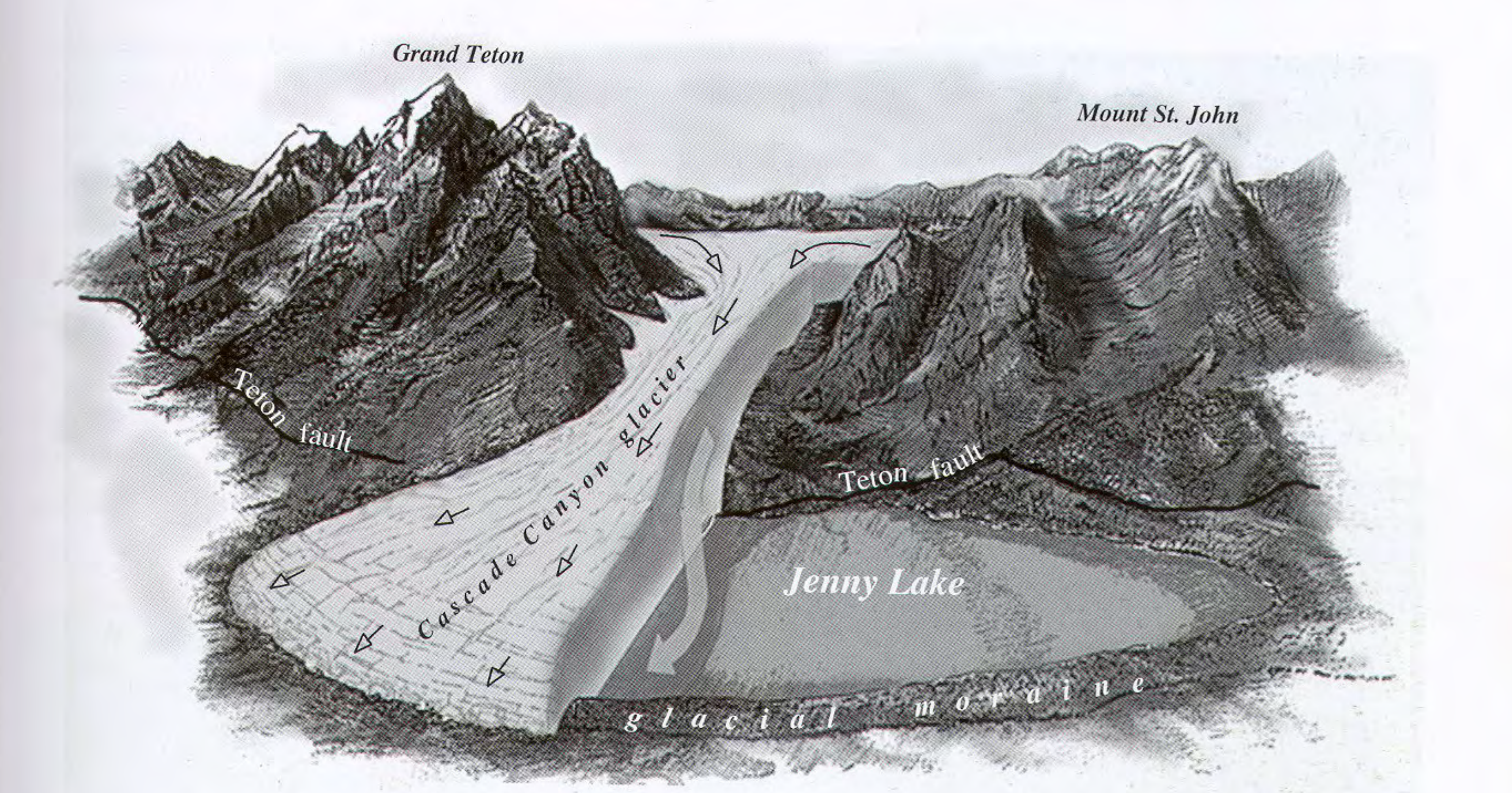
Among the glacial features within the Grand Teton Range are cirques, aretes, cols, horns and u-shaped valleys. Alpine glaciers form at the head of stream valleys, and erosion by the ice creates bowl-shaped amphitheaters called *cirques* (see photo above). These cirque glaciers erode the bedrock in headward and lateral directions, sculpting the mountains into sharp angular topography. Erosion on two opposite sides of a divide creates knife-edged ridges called *aretes*, and when glaciers eroding headward on opposite sides of a ridge coalesce, low saddles through the ridge called *cols* are formed (see figure to the right). Cirque glaciers eroding headward on three or more sides of a divide created pyramid-shaped peaks called glacial horns. The summit of the Grand Teton is an excellent example of a glacial horn (figure below). The canyons (e.g., Cascade, Paintbursh, and Garnet Canyons) that allow ready access to the interior of the Teton Range are examples of u-shaped valleys.

During retreat of the glaciers, poorly sorted and unstratified material called till was deposited by the ice. The till accumulated in ridges called moraines. Beyond the moraines, braided streams draining the retreating ice spread deposits of sorted and stratified gravel called outwash across the floor of Jackson's Hole. The difference in sorting and stratification of the material deposited causes makes differences in vegetation. The poorly stratified till retains water and supports lush green vegetation (note the dark terminal moraine at the base of the mountains in the photo to the left) while the outwash drains quickly and hence supports only prairie grass and sage brush (it appears brown in the photo).

The nearly flat sage-brush covered terrane is sometimes broken only kettle holes (shallow depressions with small lakes, marshes, or growths of evergreens). Kettles are depressions in the outwash plain created when blocks of ice were detached from the melting glaciers. Notice the hummocky ground in the foreground of the photo to the right, these are kettle lakes and marshes.



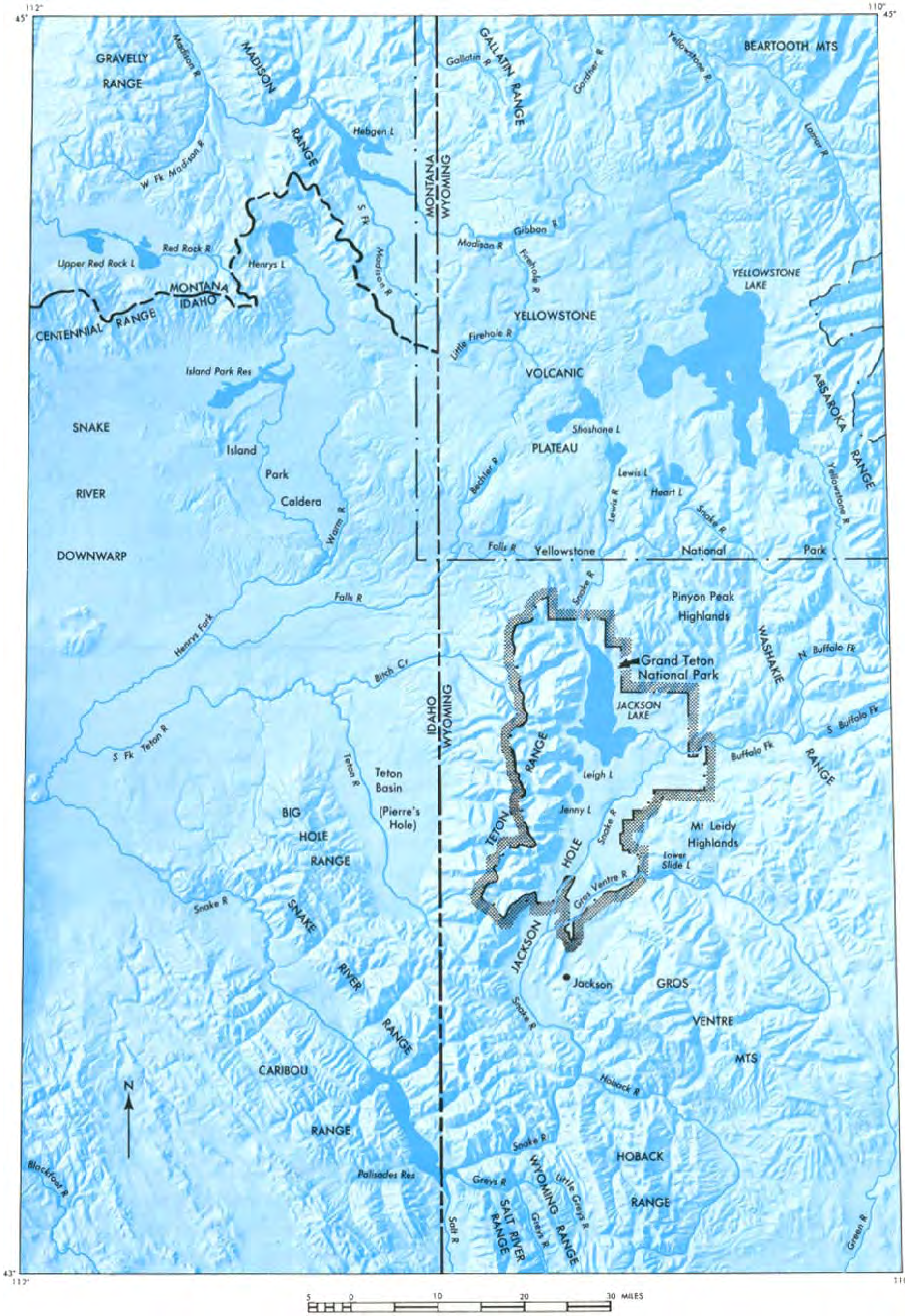
6.1 ~ *A 3,500-foot-thick icecap formed atop the Yellowstone Plateau at various times during three major glacial periods, beginning as early as perhaps 2 million years ago. During the most recent or Pinedale glaciation, roughly 50,000 to 14,000 years ago, ice (light blue) flowed south from Yellowstone and terminated in northern Jackson Hole. During the second oldest glacial stage—the dates of which are debated—ice (darker blue) was up to 2,000 feet thick in northern Jackson Hole and covered the entire valley. Small arrows show the directions of ice flow. (Adapted from Locke, 1995; Pierce, 1979; and Smith, 1993.)*



6.5 ~ *Cascade Canyon Glacier is an example of an alpine glacier that flowed east out of the Teton Range. It scoured out Cascade Canyon and deposited a moraine of debris at its base, damming a creek to form Jenny Lake. (National Park Service.)*

6.4 ~ Timbered Island is a narrow, pine-covered glacial moraine southeast of Jenny Lake. The hill, which extends north–south, was produced by the second of three stages of glaciation in Jackson Hole. As a giant glacier flowed south, it dumped rocky debris along its sides, forming lateral moraines, including Timbered Island.

An icecap as thick as 3,500 feet covered the Yellowstone Plateau, Absaroka Range, and much of the Teton Range. This icecap extended roughly 60 miles east–west, from the Absarokas to West Yellowstone, and another 80 miles north–south, from Montana south across Yellowstone to the northern Tetons and northern Jackson Hole. The surface of the icecap attained elevations as high as 10,500 feet. It covered the Yellowstone Plateau's highest peaks, including 10,243-foot Mount Washburn. In the Absaroka and northern Teton ranges, only peaks above 10,500 feet poked above the ice. It would have been a remarkable sight. Imagine flying over Yellowstone and seeing an ice field covering an area three-quarters the size of Connecticut.



112°
45°
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GRAVELLY
RANGE
Madison R
MADISON
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GALLATIN RANGE
Gallatin R
Gardner R
Yellowstone R
BEARTOOTH MTS
Lamar R
W Fk Madison R
MONTANA
WYOMING
S Fk
Madison R
Red Rock R
Upper Red Rock L
Henrys L
MONTANA
IDAHO
CENTENNIAL RANGE
Gibbon R
Madison R
Firehole R
YELLOWSTONE
LAKE
YELLOWSTONE
Little Firehole R
Island Park Res
VOLCANIC
ABSAROKA RANGE
SNAKE
Shoshone L
PLATEAU
Island
Park
Caldera
RIVER
DOWNWARP
Warm R
Bechler R
Lewis L
Lewis R
Heart L
Snake R
Yellowstone R
Falls R
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Snake R
Pinyon Peak
Highlands
Falls R
Henrys Fork
WASHAKIE
N Buffalo Fk
Grand Teton
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WYOMING
JACKSON
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Jenny L
BIG
HOLE
RANGE
Snake R
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Slide L
Gros Ventre R
Snake R
SNAKE
RIVER
RANGE
JACKSON
Jackson
GROS
VENTRE
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Snake R
CARIBOU
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Blackfoot R
Palisades Res
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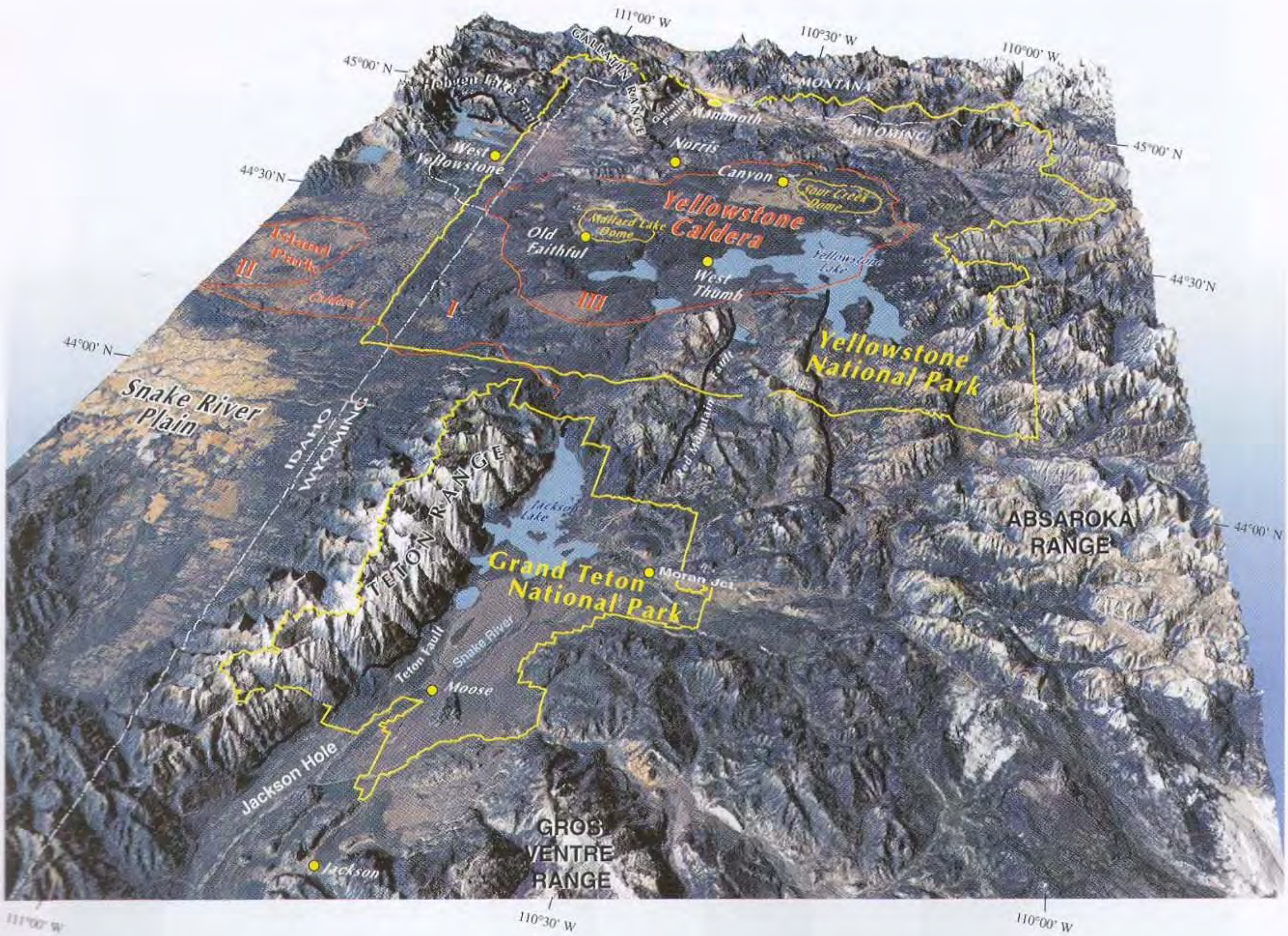


1.4 ~ *Space view of Grand Teton and Yellowstone national parks from satellite images overlaid on digital elevation maps. The 8,000-foot-high Yellowstone caldera (marked III) was produced by a giant volcanic eruption 630,000 years ago. The caldera occupies a 45-by-30-mile-wide area of central Yellowstone. The Teton fault bounds the east side of the Teton Range and raised the mountains high above Jackson Hole's valley floor. Partial boundaries of the calderas formed 2 and 1.3 million years ago are marked I and II, respectively. (Computer image by E. V. Wingert.)*

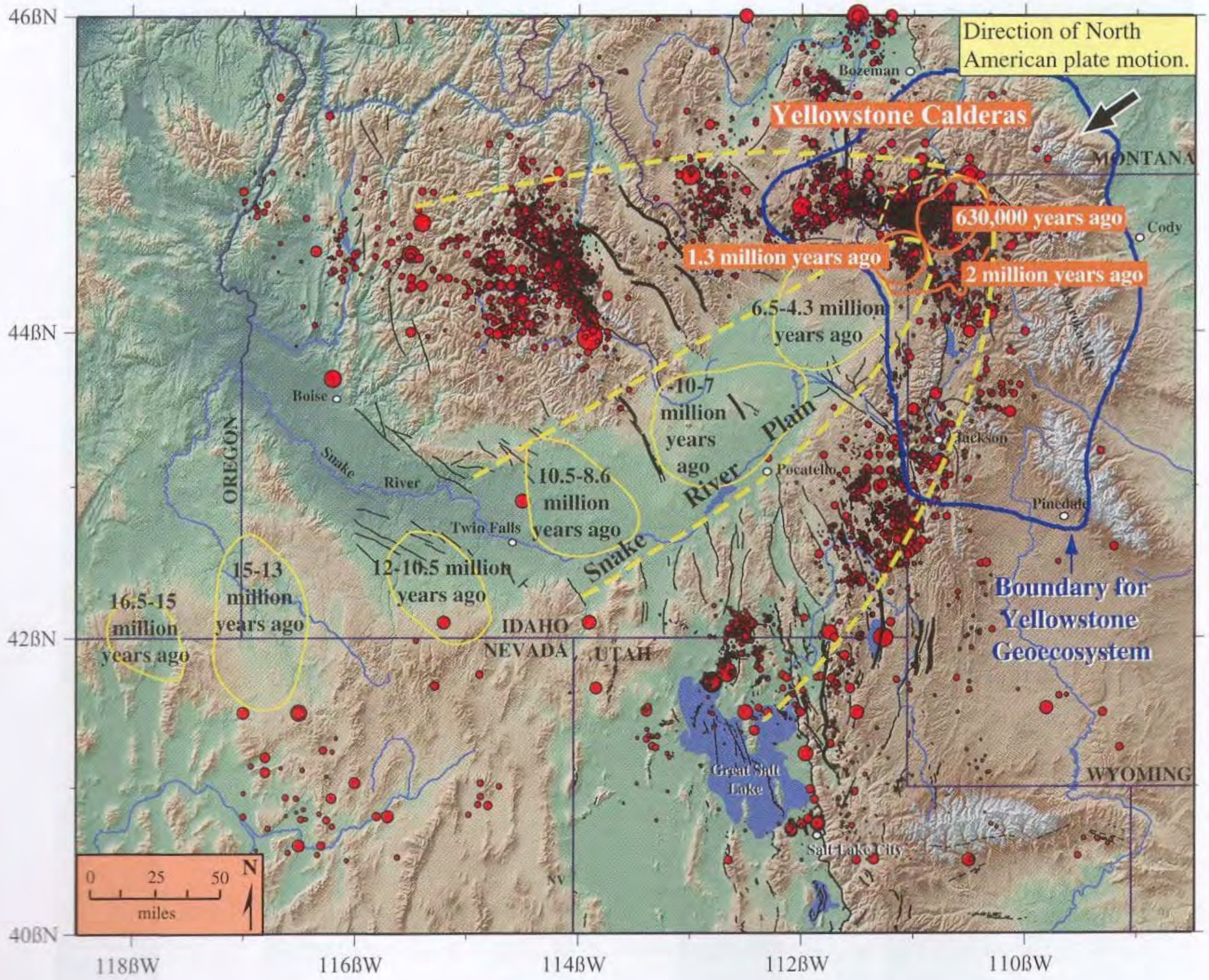
Teton Range and Jackson Lake, WY from the north

Teton Range, WY. (Left to right: Grand Teton, Mt. St. John, Leigh Lake

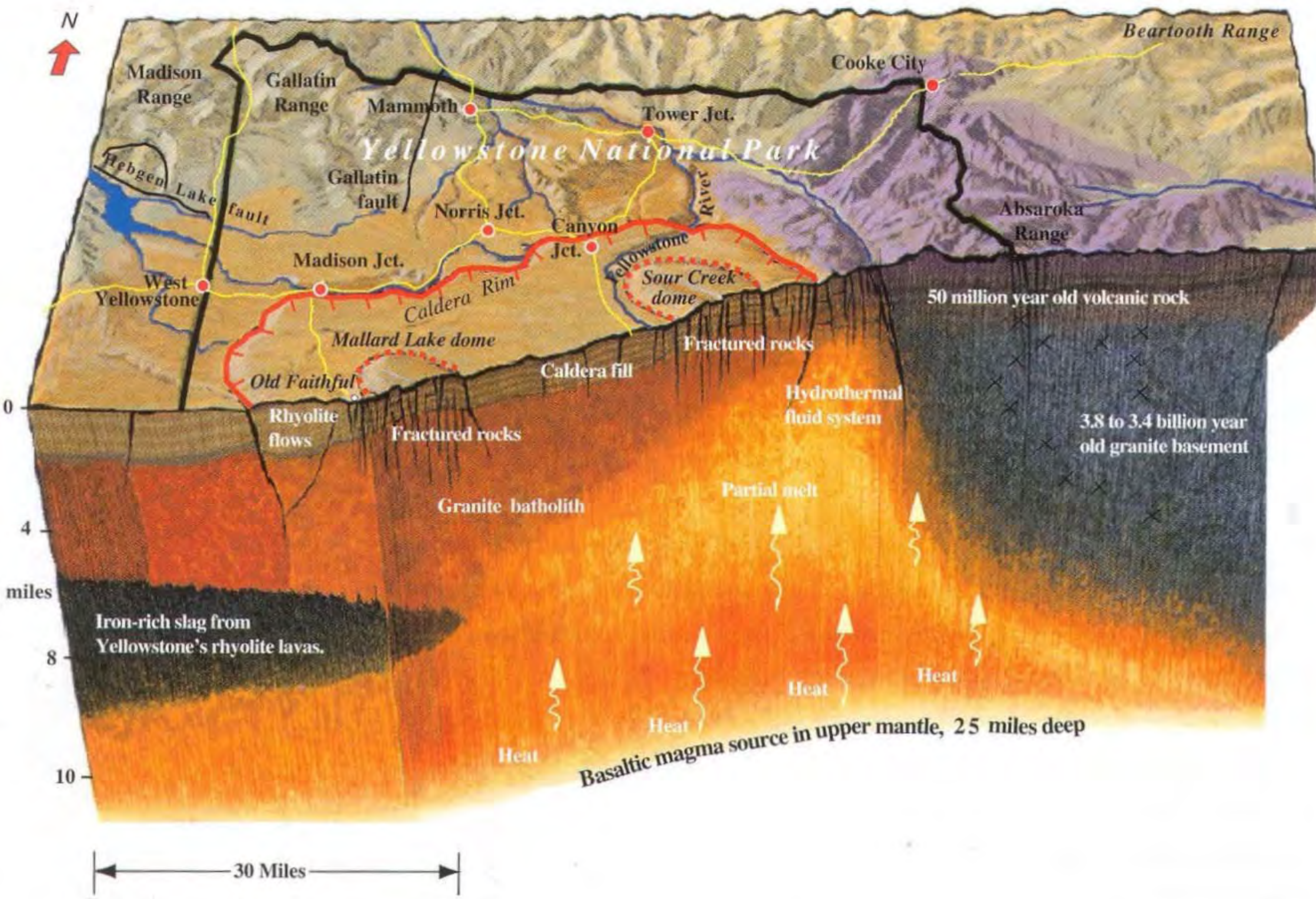
Teton Range, WY. (Left to right: Mt. St. John, Paintbrush Canyon, Leigh Lake, Leigh Canyon and south side of Mt. Moran.

Jenny Lake along the Teton Range, WY. (Left to right: Grand Teton, U-shaped valley of Cascade Creek, south flank of Mt. St. John). Jenny Lake is within the end moraine (Pinedale) of the glacier that occupied the valley of Cascade Creek.

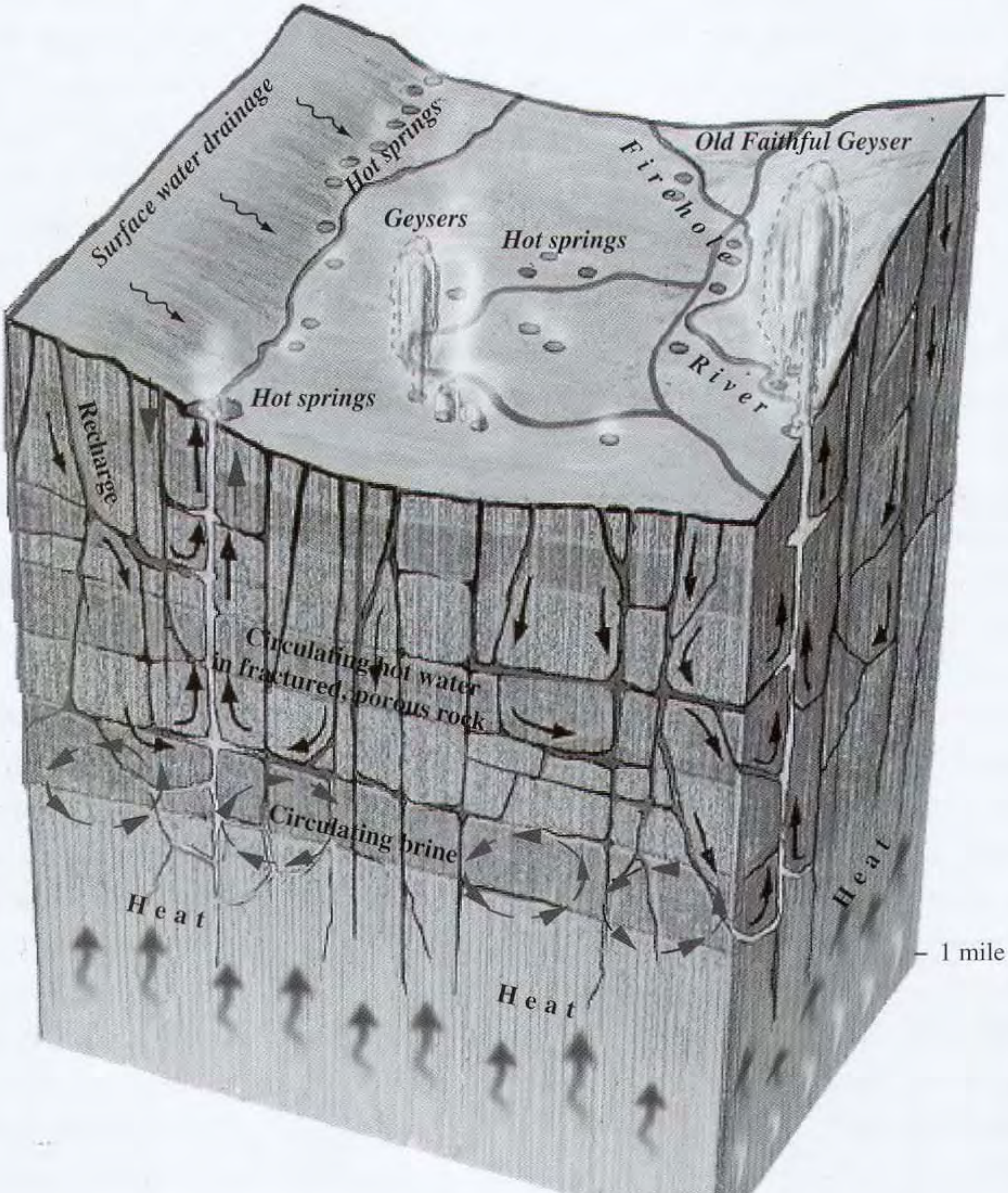
… and a little more Yellowstone geology :



1.3 ~ *Path of the Yellowstone hotspot. Yellow and orange ovals show volcanic centers where the hotspot produced one or more caldera eruptions—essentially "ancient Yellowstones"—during the time periods indicated. As North America drifted southwest over the hotspot, the volcanism progressed northeast, beginning in northern Nevada and southeast Oregon 16.5 million years ago and reaching Yellowstone National Park 2 million years ago. A bow-wave or parabola-shaped zone of mountains (browns and tans) and earthquakes (red dots) surrounds the low elevations (greens) of the seismically quiet Snake River Plain. The greater Yellowstone "geoecosystem" is outlined in blue. Faults are black lines.*



4.2 ~ *A cross section of Yellowstone reveals molten rock under the caldera at depths of about 3 to 8 miles. Heat emitted by the molten rock powers Yellowstone's geysers and hot springs.*



4.5 ~ *Workings of a Yellowstone geyser illustrate how heat from cooling magma rises to warm dense salty water circulating in a porous rock layer. The brine transfers heat to overlying fresh groundwater, which is recharged by rainfall and snowmelt. The shallow hot water can be trapped and pressurized in small underground reservoirs, then released suddenly through narrow openings, creating geysers.*