Jade State News

Wyoming State Mineral & Gem Society, Inc.

Award-Winning WSMGS Website: wsmgs.org

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Glacial Ice Ages

By Emma Groeneveld
Ancient History Encyclopedia*

An ice age is a period in which the earth's climate is colder than normal, with ice sheets capping the poles and glaciers dominating higher altitudes. Within an ice age, there are varying pulses of colder and warmer climatic conditions, known as "glacials" and "interglacials." Even within the interglacials, ice continues to cover at least one of the poles. In contrast, outside an ice age, temperatures are higher and more stable, and there is far less ice covering the Earth.

The Pleistocene Epoch is typically defined as the time period that began about 2.6 million years ago and lasted until about 11,700 years ago. The

Woolly mammoth is the most recognized of the glacial ice-age animals. Credit: Yukon Beringia, https://beringia.com

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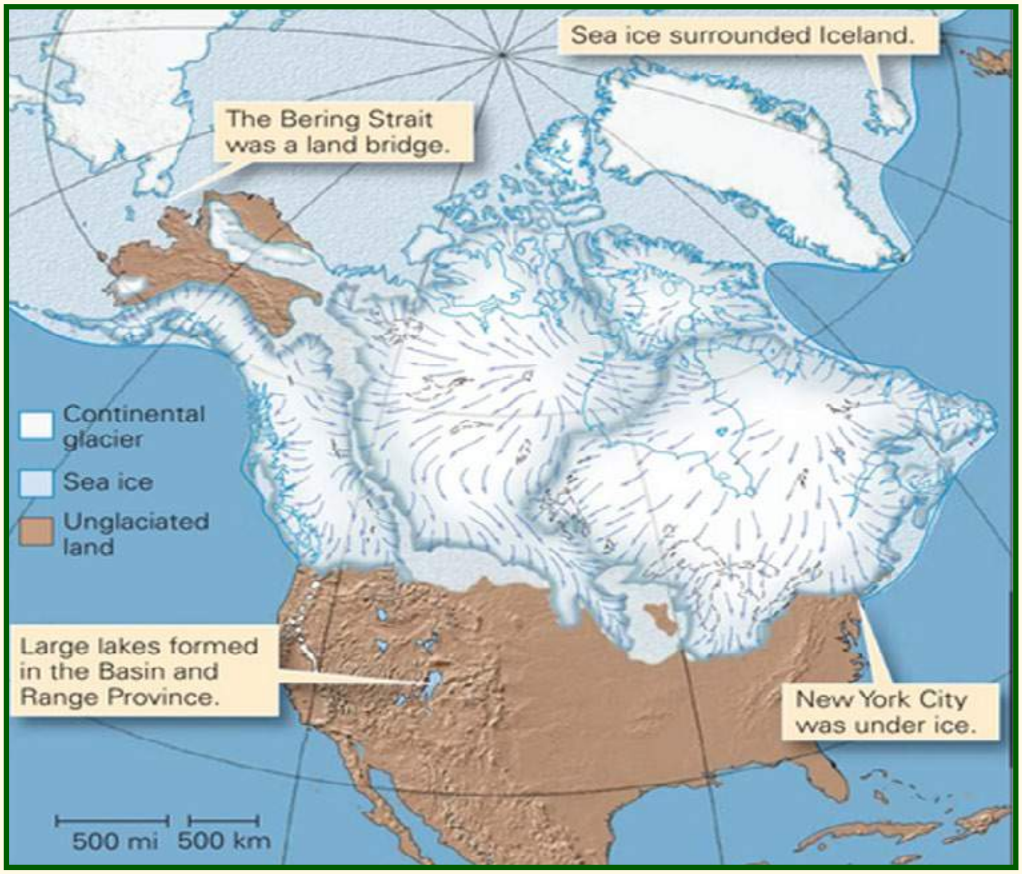

Illustration by people.uwplatt.

most recent Ice Age occurred then, as glaciers covered huge parts of the planet Earth.

There have been at least five documented major ice ages during the 4.6 billion years since the Earth was formed — and most likely many more before humans came on the scene about 2.3 million years ago.

The Pleistocene Epoch is the first in which Homo sapiens evolved, and by the end of the epoch humans could be found in nearly every part of the planet. The Pleistocene Epoch was the first epoch in the Quaternary Period and the sixth in the Cenozoic Era. It was followed by the current stage, called the Holocene Epoch.

One glance at our icy poles and frozen peaks makes it clear that our current epoch (the Holocene, c. 12,000-present day) actually represents an interglacial within the ice age that spans the Quaternary geological period, which started around 2,6 million years ago and encompasses both the Pleistocene (c. 2,6 million years ago - c. 12,000 years ago) and the Holocene epochs. This entire period is characterized by cycles of ups and downs in ice sheet volumes and temperatures which can sometimes change as much as 15°C within a couple of decades. This rapidly overturning climate can have huge changes all around the world, altering vegetation and the types of animals that can survive in certain areas, and it helped shape human evolution, too. It is because of its connection with the early existence of humans, that this definition will largely focus on the Quaternary ice age, and mostly on its affect on humans adaption to this unfamiliar world of the Pleistocene, with its magnificent mammoths and long-toothed cats surviving alongside early human hunter-gatherers weaving their way through these volatile conditions.

[PHOTOS of animals interacting]

Glacial Climates

After the Antarctic ice sheet first began to spread its chilly fingers through the world's oceans around 38 million years ago, the cooling oceans allowed for the earth's temperature swings to become stronger and stronger. A major cooling-down occurred around 2,6 million years ago at the start of the Quaternary, and was followed by ice ages: c. 1,8 million years ago, c. 900,000 years ago, and c. 400,000 years ago, which resulted in even greater climate changes. Overall, the climate was much colder and drier than it is today. Since most of the water on Earth's surface was ice, there was little precipitation and rainfall was about half of what it is today. There were winters and summers during that period. The variation in temperatures produced glacial advances, because the cooler summers didn't completely melt the ice.

This increasing strength is especially noticeable from around 900,000 years ago onwards, as it was not until this point that major glaciations — with sweeping ice

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Intercontinental Glacial Ice Ages

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sheets covering higher altitudes across Eurasia and North America — became common features of the Quaternary ice age. From this time on, survival was definitely no walk in the park but required coping with much more extreme conditions. During the cold swings, temperatures could reach up to a terrifying 21°C (70 degrees Fahrenheit) COLDER than the present, although the average lies closer to 5°C (9 degrees Fahrenheit) COLDER than today. During Quaternary glaciations in general, because of the amount of water stuck in frozen form, sea levels could be up to 120 meters (394 feet) LOWER than they are now. A lot more land was thus left uncovered for species to explore, and places such as the British Isles could suddenly be reached because the North Sea would turn into a sort of North Land during these times. Meanwhile, while the earth's northern reaches were covered by tundra, Africa became drier.

Glacial climates — which varied in strength, effect, and affected different areas in different ways — generally crept up quite gradually, beginning with cooler and wetter conditions that eventually climaxed in a cold and dry phase. The ice sheets grew so thick that they would cling on for a while into the start of a warming trend, only to collapse suddenly, leading to a very sudden switch into an interglacial period. Temperatures could then remain moderate for a longer period of time during which the world saw higher sea levels and actually accessible higher latitudes. During the last ~1,2 million years, these cycles were generally around 100,000 years in length. For animal species to be able to adapt to these changing conditions is not an easy task, especially considering the speed at which things could change.

Glacial Animals

The most recognized animal of the Pleistocene is the woolly mammoth; huge, towering, curved-tusked, shaggy-coated foragers related to elephants. They actually originated in Africa and during the Pleistocene set out on a trek towards the northern tundras. They were not the only species that flourished during this period.

The appearance and expansion of, among others, the genus Equus (which includes horses and zebra), bison, aurochs, hippopotamus, giant ground sloths, voles, the deer family (among which oversized versions such as Megaloceros or Giant Deer, and the moose genus), and the second woolly powerhouse — the woolly rhinoceros — filled in the prehistoric landscape.

In addition to the woolly mammoth, mammals such as saber-toothed cats (Smilodon), giant ground sloths

Ice age animals on the move.

Illustration by

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Intercontinental Glacial Ice Ages

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A sabertooth cat chases its prey.

Illustration by

(Megatherium) and mastodons roamed the Earth during this period. Other mammals that thrived during this period include moonrats, tenrecs (hedgehog-like creatures) and macrauchenia (similar to a llamas and camels).

The predators wanting to feast on such diversity did not lag behind; sabre-toothed cats munched away on prey throughout the Pleistocene, and lions ranged all the way from southern Africa to southern North America during the late Pleistocene, including cave lions that lived all the way from Europe to western Canada. Cave bears and cave hyenas could be found throughout Europe and Asia up to the northeast of Siberia.

Animal extinctions

Such diversity is hard to imagine from our own point of view, in a time when humans have shaped the world to suit their own needs to such an extent the habitats of many animals have already shrunk or disappeared completely. Indeed, a lot of the creatures named above have long since vanished from the face of the earth. Quite a few of the big ones, in particular, collectively referred to as the Pleistocene megafauna, seem to have dwindled and died out towards the end of the Pleistocene in a massive extinction event.

The last of the cave bears seem to have met their end somewhere between c. 30,500 - c. 28,500 years ago, around the time of the Last Glacial Maximum (the most recent glacial, in which the ice sheets reached peak growth between c. 26,500 to c. 19,000 years ago). In fact, the northern reaches of Eurasia saw as much as around 37% of species weighing upwards of 44 kg disappear from this time onwards. Species such as cave lions and woolly rhinoceros clung on until c. 14,000 years ago, the latter already having retreated far into northeastern Siberia as a final refuge by this time, seemingly having trouble dealing with the late-glacial warming climate (which also affected the plants it normally ate).

Mammoth actually survived into the Holocene (alongside the Giant Deer, which is last known from the Urals in Siberia around 7700 years ago), and then pushed back to a last retreat at Wrangel Island in Arctic Siberia where it finally gave in c. 3600 years ago. This is one species on which the impact of climate change can clearly be seen, as after the Last Glacial Maximum ended, the warmer conditions seem to have made a serious dent into the mammoths' climatic niche, and their numbers plummeted. We know that humans also hunted them quite successfully, and it seems the challenging climate left the mammoths quite vulnerable.

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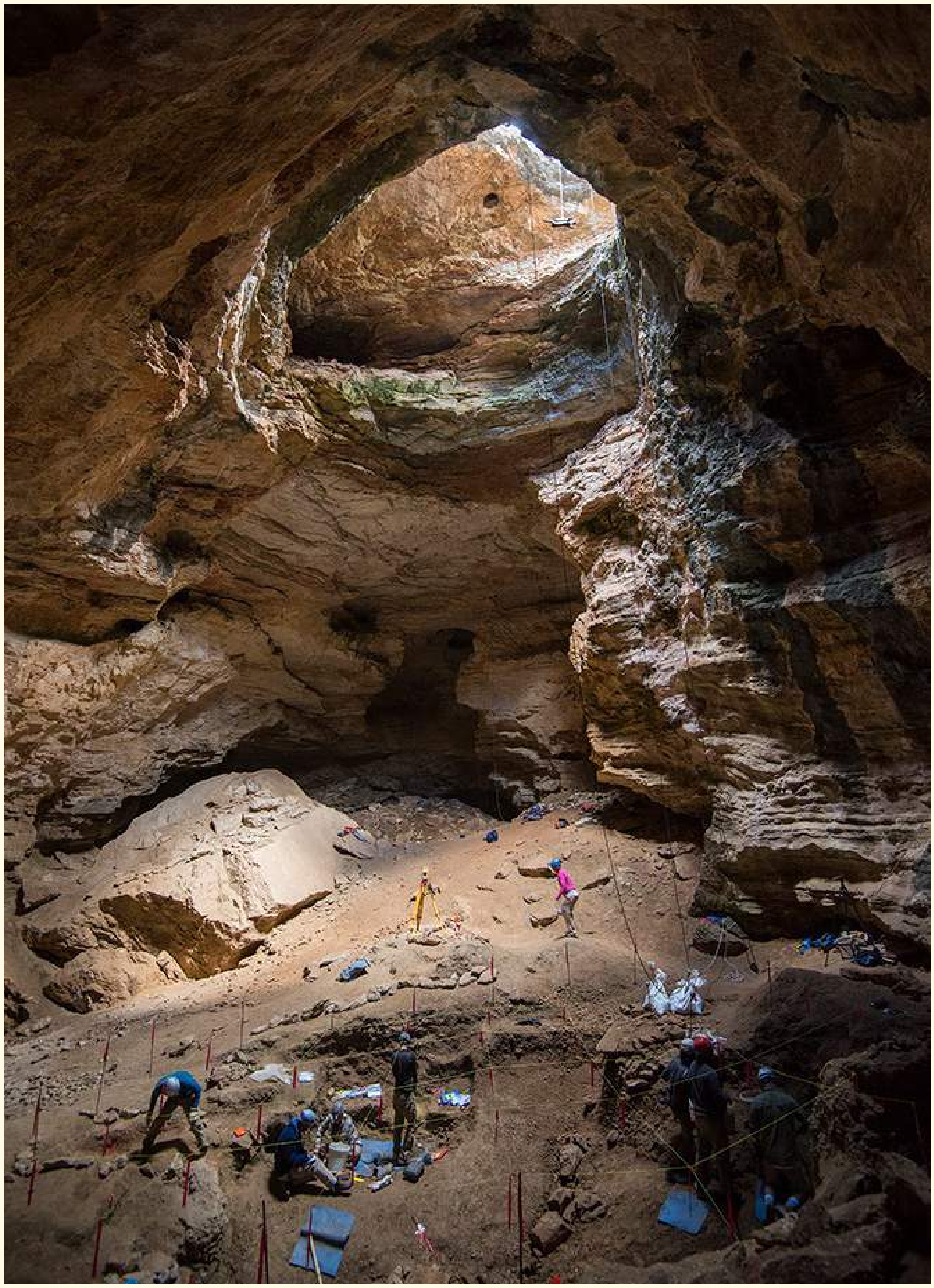
Natural Trap Cave preserves Wyoming's Ice Age animals



Scientists in 2016 carefully dig and brush away debris from the bones of countless Ice Age animals that fell to their deaths in the Natural Trap Cave in the Big Horn Mountains in Wyoming. Photo courtesy of Dennis Davis of Powell, Wyoming

Their lives were cut short by a fatal fall thousands of years ago, but their stories may yet be brought to light from the Natural Trap Cave in the foothills of the Big Horn Mountains.

The cave is a sinkhole, a deep cavity in Madison limestone carved by water erosion for thousands upon thousands of years.

Animals — hunter and hunted — plunged to their death when they inadvertently stumbled into the 15-foot-wide void. Their bones — preserved in the natural refrigerator — date back to the Pleistocene (1.64 million to 10,000 years ago) and Holocene (10,000 years ago to today) epochs.

Natural Trap Cave offers a scientific record of the ice age animals that frequented Wyoming during the late Pleistocene, many of which are extinct today. The vertical cave that has ensnared countless animals.

The cave opening is 15-foot wide by 90 feet deep that formed in ancient limestones uplifted during the formation of the northern Bighorn Mountains over millions of years.

During the Pleistocene Epoch and continuing into the Holocene, numerous different species and specimens of Ice Age mammals fell into this cave, typically dying on impact. The result of this geological trap is an incredibly dense and diverse trove of fossils of animals that have fallen through the hole over the millennia — a pile of bones some 10 meters (33 feet) high.

The sediments within Natural Trap

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Natural Trap Cave

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Cave are stratified, meaning that the layers were formed in chronological order, with the newest layer on top. Armed with this knowledge and additional research, scientists have identified not only how old the bones and fossils are, but also what kind of environments the extinct animals lived in. Evidence from the cave reveals that within a span of just 500 years, the region's climate went from glacial to the current high desert.

The constantly cool and moist conditions in the cave have allowed for excellent preservation of the animal's remains. Natural Trap Cave is unique in that it's climate is perfect for preserving the DNA of the large numbers of different species that have been identified which only has not been found anywhere else except Siberia and the Arctic.

It's possible now to extract and possibly sequence some of the animals' DNA, as well as look for other chemical clues — like the ratios of isotopes in their teeth and bones to learn about their diet. And with likely 100,000 years' worth of fauna to work with, evolutionary biologists may be able to see how ancient animals changed over time, adapting and responding to the last Ice Age, as well as its end.

New research efforts will examine DNA from the animals, which could help explain how the animals are related—both to each other and to modern animals. The researchers, led by Des Moines University paleontologist Julie Meachen, said that this genetic data along with other information, such as clues about the region's historical climate, will help them better understand why so many of these strange animals went extinct during the late

Ben Witt brushes away dirt during research in the Natural Trap Cave in July, 2016. Courtesy Photo by Dennis Davis

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Natural Trap Cave

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Right: Scientists conclude the 85-foot ascent up to the top of the Natural Trap Cave after a day of exploration and research. Scientists and students from Australia and the United States participated in the research project in July 2017, assisted by experienced cavers.

Below: Laura Vietti holds the jawbone of a cheetah that perished in the Natural Trap Cave. Photos courtesy of

Pleistocene, some 11,000 years ago.

Most of the mammals trapped in this cave are extinct now, including the American cheetah (similar to today's cougars), American lion, Columbian mammoth, short-faced Bear, Beringian wolf, bison, camels, musk-ox, and several types of Ice Age horses.

Fossils include an American lion that weighed 900 pounds. "It's the largest cat that ever lived," said Julie Meachen, assistant professor at Des Moines University in Des Moines, Iowa, DNA says the American lion is most closely related to the African lion, she said.

Meachen and Alan Cooper, of the Australian Centre for Ancient DNA, were the lead scientists at the cave site.

But several of the species found in this cave are still living in the area today, including modern pronghorn, rodents, coyotes, fox, and bighorn sheep, among others.

This extremely rare collection of preserved Ice Age fauna is providing researchers a unique look at Ice Age ecosystems and paleoclimates, as well as allowing refinement of information on Pleistocene mammalian DNA and evolution during a critical time in the history of our planet.

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Wyoming Valley Glaciers

By Stan Strike

During the Pleistocene Ice Age (~1.8 million years to 10,000 years ago), the Wyoming Rockies were covered by large ice caps (Breckenridge, 1973) that carved the valleys and created the topography we see today. Only the tallest peaks were not completely covered by ice. The best known Pleistocene Glaciations are the Bull Lake Glaciations (~140,000 years ago) and the Pinedale Glaciations (~30,000 years ago) (Pierce et al., 1976). These glaciations were named after the locations where the evidence for their existence was first discovered (Bull Lake, WY, and near Pinedale, WY).

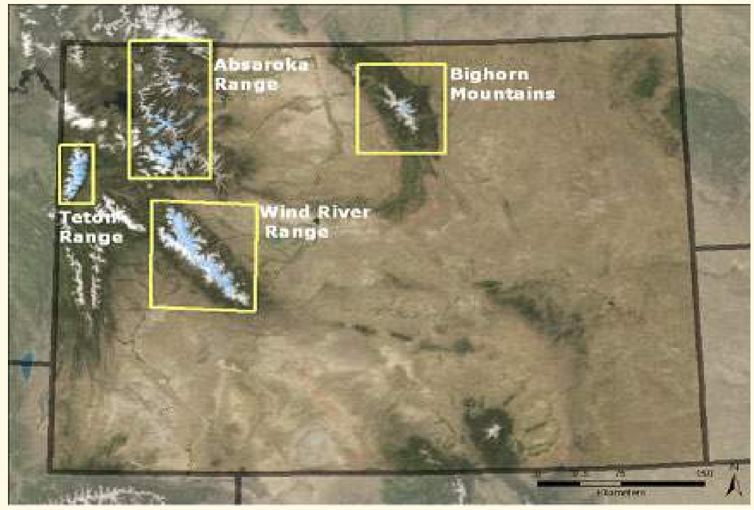
The most recent period of glacier advances occurred during the "Little Ice Age," which occurred during the 13th Century (1200's) to the 19th Century (1800's) during which the northern hemisphere of Earth experienced a widespread cooling period. The primary cause of the" Little Ice Age" may have been the Mount Salamas volcanic eruption, which took place in Lombok, Indonesia in 1257. It is thought that volcanic ash particles in the upper atmosphere limited the amount of sunlight that reached the Earth. After this one single event, countries around the world were affected in different ways. Weather and climate changes in some regions were beneficial whereas in other regions, peoples were forced to migrate in order to survive.

Since the end of the "Little Ice Age" and the early 20th century, the glaciers of the Wyoming Rocky Mountains have been generally retreating-making them smaller in size and creating less water outflow in the future.

Wyoming's Valley Glaciers

During the Little Ice Age the large Continental Glaciers had retreated by melting back towards the poles and only isolated glacial remnants remained. These areas often were found at the upper elevations of large valley drainages. In these areas, snow was able to accumulate annually and be transformed into glacial ice. Valley glaciers are streams of flowing ice that are confined within steep walled valleys, often following the course of an ancient river valley. The downward erosive action of the ice carves the valley into a broad U shape, in contrast to the steeper V shape that is produced during the early stages of erosion by rivers.

Wyoming is home to the largest valley glacier in the Rocky Mountains, and the second-largest in the continental United States. Gannett Glacier lies in the Wind River Range in central Wyoming, northeast of Gannet Peak (the highest peak in the state). The glacier is currently about 3.3 square kilometers (1.27 square miles) in area; it was 4.6 square kilometers (1.78 square miles) in 1950, making it a retreating glacier. Glaciers are constantly accumulating ice at their head and melting at their terminus (foot). When the amount of melt is higher than the amount of ice formation, the glacier shrinks and retreats.



Wyoming's valley glaciers by mountain range. Illustration by Blue Marble

There are 38 named glaciers across Wyoming. Most of them are in the Wind River Range, with a few in the Teton and Absaroka ranges. Evidence of past glaciation does, however, exist in many mountainous areas across the state and can be found by looking for clues left by the long-gone glaciers.

Glaciers carve out characteristic U-shaped valleys (an example is Sinks Canyon, near Lander), as opposed to the V-shaped valleys created by rivers. Rocks left behind by glaciers can be distinctive in several ways as well. As glaciers retreat, they leave behind mounds of sediment in features called moraines. This sediment, known as glacial till, can vary widely in composition and size because glaciers pick up everything the ice passes over, including very large boulders. As rocks are carried along within a glacier, they bump and slide past each other. This action can create striations (long linear groves), chatter marks (impact marks), and other evidence of their movement. The rocks in the glacier also grind against one another, creating a fine powder called glacial flour. This glacial flour is very

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Wyoming Valley Glaciers

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light and stays suspended when it enters glacial lakes and streams. The light reflecting off the particles gives glacial melt water its characteristic light-blue and green color.

The most scenic features left behind by glaciers are glacial lakes. These lakes can be high in the mountains and are often deep and clear. As the glaciers receded, they left moraines surrounded by steep mountain terrain. In many cases the moraines trapped water, creating lakes in dramatic alpine settings. A trip to the high country usually involves a visit to a glacial lake, which we can all look forward to next summer.

There are more than 1400 permanent snow or ice bodies in Wyoming, of which 110 are larger than 0.1 km2. There are 38 named glaciers: 1 located in the Bighorn Mountains, 2 in the Absaroka Mountains, 10 in the Teton Range, and 25 in the Wind River Range. The total area of Wyoming covered by permanent snow or ice bodies is roughly 73 km2, making it the second-most glaciated of the lower 48 states. The glaciated areas of Wyoming range from 42.6 to 45 degrees north and -107.1 to -110.9 degrees west.

[Note: all statistics here are based on USGS 1:24,000 scale topographic quadrangle maps which are based on mapping photography from dates between 1949 and 1994.]

Wind River Range

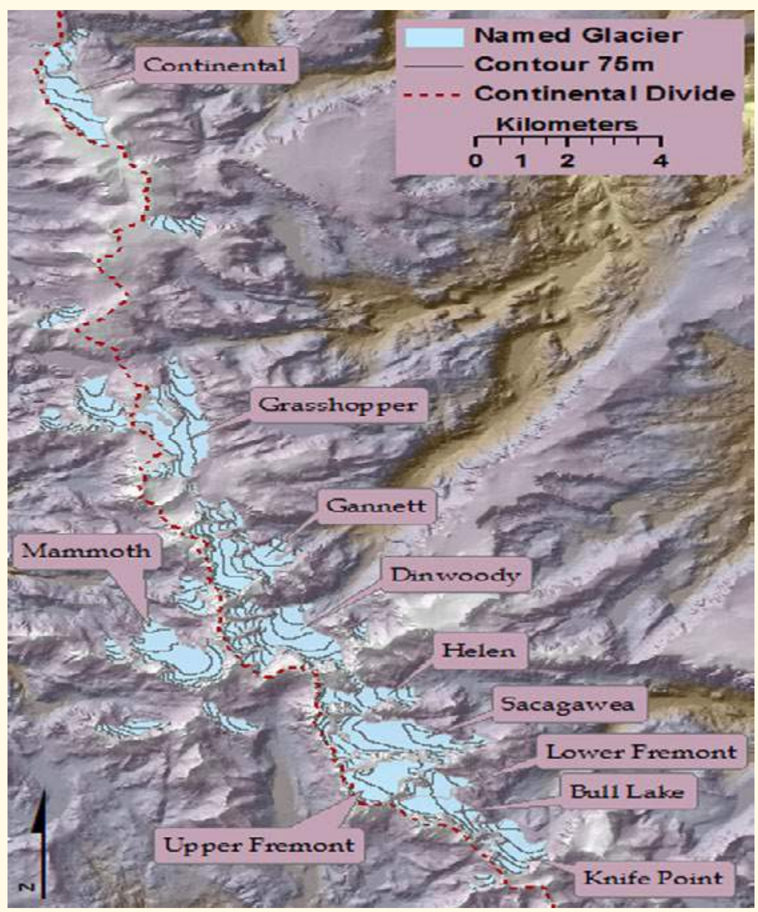
The Wind River Range spans 210 km along the continental divide in western Wyoming. Roughly 680 snow and ice bodies are located in the Winds, with a minimum elevation of 3113 m, maximum elevation of 4205 m, and mean elevation of 3536 m. The combined area is 55.8 km2. The range contains 25 of Wyoming's 38 named glaciers, including Gannett Glacier (3.3km2), the largest glacier in the continental U.S. outside of Washington State. In fact, seven of the ten largest glaciers outside of the state of Washington are located within the Wind River Range. The Continental Divide runs the length of the Range and melt water runoff flows to two different Oceans, Atlantic and Pacific. The western slopes contribute to the Colorado River Basin flowing into the Gulf of California, while the east slopes contribute to the Missouri River Basin flowing into the Gulf of Mexico. The glaciers located in the Wind River Range are considered a vital water source to eastern Wyoming during the dry summer months and years of low precipitation.

Most of the glaciers located in the Wind River Range are north or east facing and found on the east slope of the continental divide. In the highest parts of the Winds, average annual snow fall is roughly 500cm. In 1991 and 1998 the USGS drilled Upper Fremont Glacier to collect ice cores, which provided a record of the atmospheric conditions spanning 270 years.

Teton Range

The Teton Range spans 65 km in western Wyoming along the Wyoming - Idaho border. There are roughly 276 permanent snow and ice bodies with a minimum elevation of 2694m, maximum elevation of 4096m, mean elevation of 3127m, and a combined area of 6.9 km2. The Tetons contains 10 of Wyoming's 38 named glaciers, the largest of which is Teton Glacier (0.30 km2).

The majority of the glaciers in the Tetons have north or east aspect, with the exception of Falling Ice Glacier on Mount Moran, which faces southeast. All the glaciers are located on the east slope of the mountain range, and like



Eleven of the largest named glaciers in the Wind River Mountain Range.

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Wyoming Valley Glaciers

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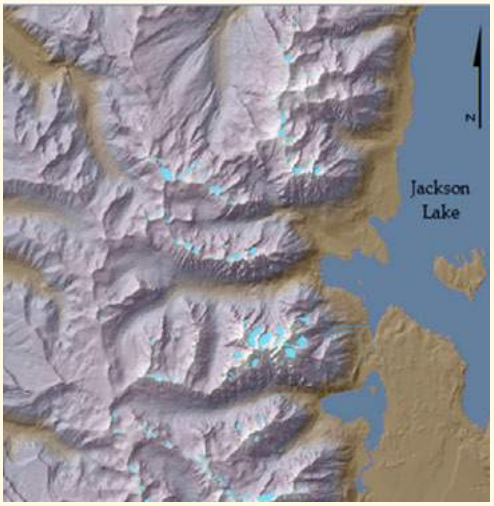


Permanent snow and ice bodies located within the Teton Mountain Range.

the glaciers of the Wind River Range, this is most likely due to the decreased solar radiation and predominantly westerly winds (Fryxell, 1935).

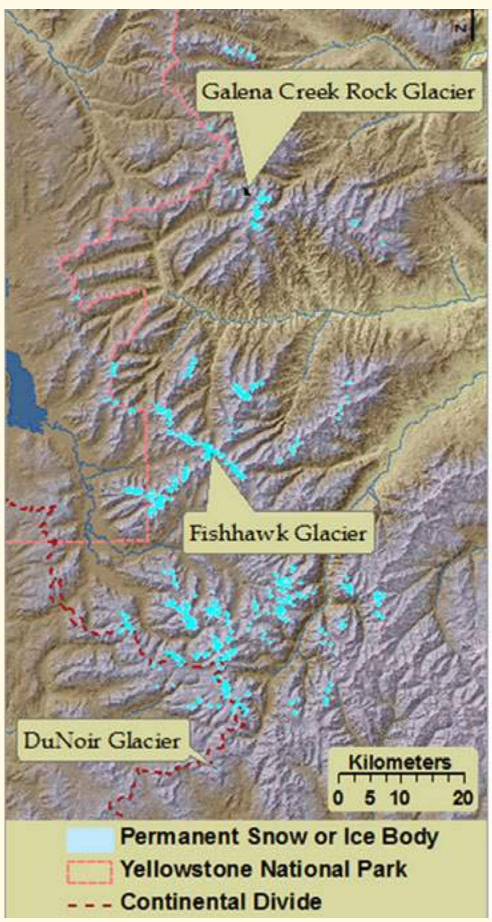
Absaroka Mountains

The Absaroka Mountains span 240 km along the eastern border of Yellowstone National Park in northwestern Wyoming and southern Montana. There are roughly 506 snow and ice bodies with a total area of 9.6 km2. Minimum elevation is 2803m, maximum elevation is 3664m, and mean elevation is 3273m. The Absaroka Mountains contain 2 of Wyoming's 38 named glaciers, the larger of which is Fishhawk Glacier (0.25km2). The Absaroka Mountains also contain the well studied Galena Creek Rock Glacier (Ackert, 1998; Potter et al., 1998).

Big Horn Mountains

The Big Horn Mountains span 320 km in central northern Wyoming and southern Montana. The Big Horns contain roughly 16 snow and ice bodies with a total area of 0.97 km2. They have a minimum elevation of 3197m, maximum elevation of 3730m, and mean elevation of 3415m. The Big Horn Mountains contain only 1 of Wyoming's 38 named glaciers, Cloud Peak Glacier (0.23km2). Rahn et al. (2006) estimated that if the melting continues at the rate that was calculated in 2005, Cloud Peak Glacier will disappear completely sometime between the years 2020 and 2034.

The area of Gannett Glacier has been reduced by roughly 44.8% between the end of the "Little Ice Age" and 2001.



Permanent snow and ice bodies located within the Absaroka Mountain Range.

Permanent snow and ice bodies located within the Big Horn Mountain Range.

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Paleontology in National Parks

Condensed from an article by Steve Voynick
Rock and Gem Newsletter, Sept. 16, 2019
www.rockngem.com/paleontology-in-the-parks/

Our national parks and national monuments are a treasure trove for anyone interested in fossils and paleontology. Although most of the National Park Service's 177 parks and monuments are involved with fossils in some manner, ten exist specifically to protect, preserve, study, and interpret paleontological resources.

The ten paleontology-oriented parks and monuments represent a huge span of geological time from the late Triassic Period 225 million years ago to the Pleistocene ice ages just 15,000 years ago. The fossils they display range from tiny insects to the bones of huge dinosaurs. The largest of these "paleontology parks" covers 379 square miles, the smallest just a few acres. The oldest dates to 1906; the newest was established only in 2015.

The following is a listing of the 10 National Parks and Monuments featured in the original article listed with internet links for each in order to provide additional information.

- Petrified Forest National Park (NE Arizona): www.nps.gov/pefo
- Fossil Butte National Park (SW Wyoming): www.nps.gov/fobu
- Dinosaur National Monument (NW Colorado): www.nps.gov/dino
- Florissant National Monument (SW Colorado): www.nps.gov/flfo
- Hagerman Fossil Beds National Monument (SW Idaho): www.nps.gov/hafo
- Agate Fossil Beds National Monument (West Central Nebraska): www.nps.gov/agfo
- Tule Springs Fossil Beds National Monument (SE Nevada): www.nps.gov/tusk
- John Day Fossil Beds National Monument (East Central Oregon): www.nps.gov/joda
- Badlands National Park (Southwest South Dakota): www.nps.gov/badl
- Waco Mammoth National Monument (SE Texas): www.nps.gov/waco

2021 Rock Shows in Wyoming

This summer, rock hounds can attend three rock shows in Wyoming, including the joint national and regional mineralogical society shows in June and the state rock show in July

• **May 15-16** — Cheyenne Mineralogical, Gem & Rock Show, hosted by the Cheyenne Mineral and Gem Society in the Archer Complex Building M, 3967 Archer Parkway, Cheyenne, Wyoming. Friday and Saturday 9 a.m. to 5 p.m.; Sunday 9 a.m. to 4 p.m.

Contact: Jan Shively, cmgstreasuer@gmail.com or 509-953-0634.

• **June 18-20** — "Rock and Roll with Wyoming Rocks," hosted by the Sublette County Rock Hounds at the Sublette County Fairgrounds Event Center, 10937 U.S. Hwy 189, in Big Piney, Wyoming.

This rock show also serves as the joint annual conventions of the American Federation of Mineralogical Societies and the Rocky Mountain Federation of Mineralogical Societies. Friday and Saturday 9 a.m. to 5 p.m.; Sunday 9 a.m. to 4 p.m.

Contact: Jim Gray, 307-260-6442, or Leane Gray, 307-260-6443.

• **July 9-11** — 73rd annual Gem and Mineral Show and the 2021 Wyoming State Mineral and Gem Society show, hosted by the Casper rock club at the Ramkota Hotel, 800 N. Poplar in Casper, Wyoming. Friday and Saturday 9 a.m. to 5 p.m.; Sunday 9 a.m. to 4 p.m. Contact: Mac Goss, macogre13@yahoo.com or 307-439-9873.

See show flyers beginning on Page 20

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The Geology of Boysen State Park

A publication of the Wyoming State Geological Survey

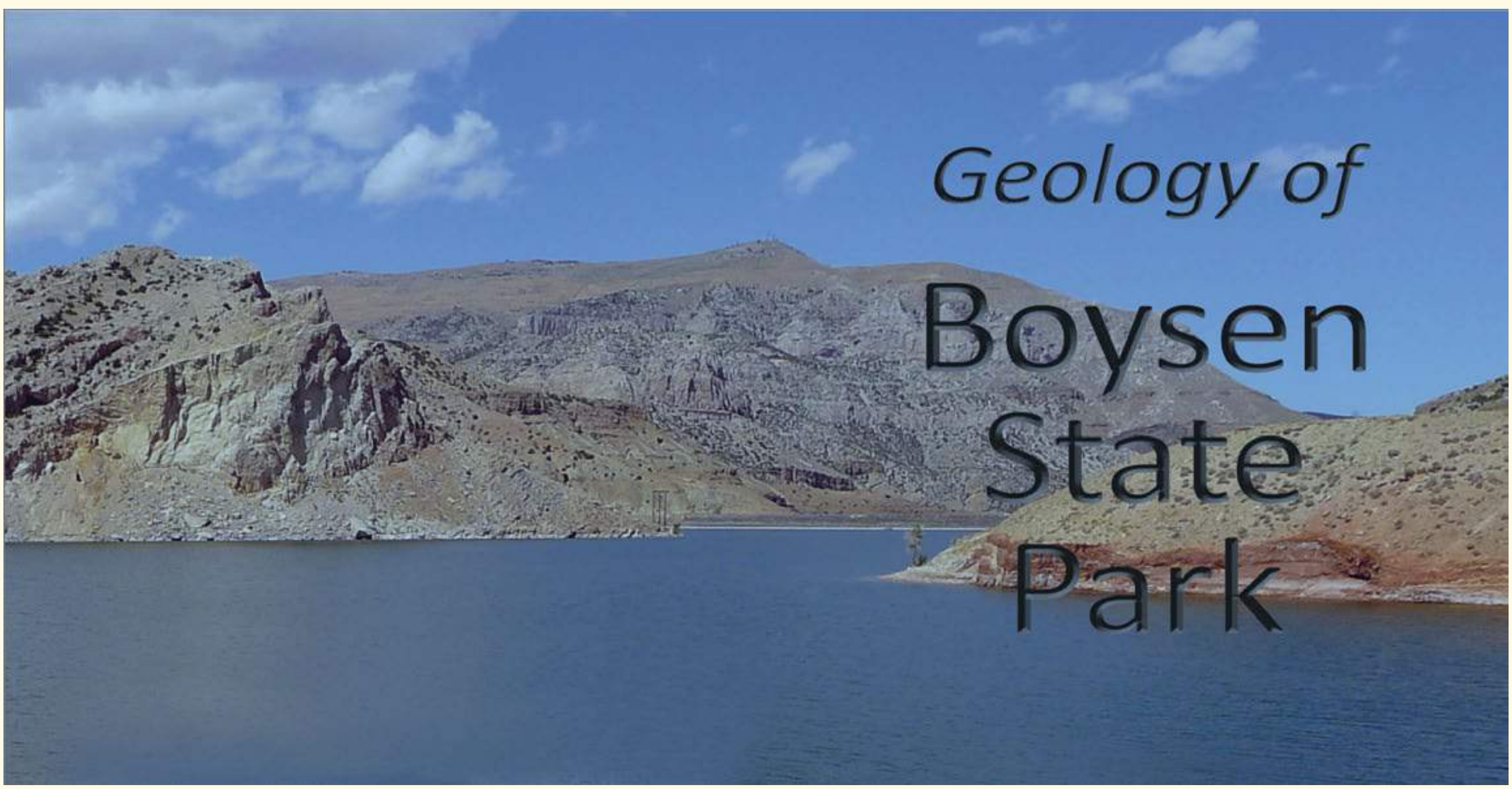
INTRODUCTION

Boysen State Park is situated on the southern flank of the Owl Creek Mountains in central Wyoming. The park encompasses Boysen Reservoir and is the gateway to the spectacular geology of Wind River Canyon. Geologic units in and around the park range from 2.9-billion-year-old rocks to modern flood plain deposits.

GEOLOGIC HISTORY

The park is at the northern edge of the Wind River Basin, a broad depression that formed in response to the Laramide orogeny. The Laramide orogeny was a mountain-building event that occurred between 70 million and 35 million years ago. During this event, Precambrian crystalline igneous and metamorphic rocks and overlying sedimentary strata were uplifted and displaced southward along the Owl Creek thrust fault, shaping the Owl Creek Mountains. Through time, the uplifted rocks eroded and were transported by rivers into the Wind River Basin, forming the Eocene Wind River Formation (53–51 million years old). The multicolored to light-brown claystones, siltstones, and interbedded sandstones of the Wind River Formation are exposed in the hills around the park and as islands within Boysen Reservoir. The overlying green and gray claystones, sandstones, and conglomerates of the Eocene Wagon Bed Formation (approximately 51–49 million years old) were deposited predominantly in ancient lakes within the basin.

Also during the Laramide orogeny, a series of normal faults formed north of the Owl Creek thrust fault, the most prominent being the Boysen fault. Unlike thrust faults, normal faults form when the earth's crust experiences tensional, or pulling apart, forces. In this case, normal faults developed as rocks transported to the surface by the Owl Creek thrust fault deformed and folded downward. Dark-colored Precambrian rocks are



Boysen State Park is located between Shoshoni, Wyoming, and the Wind River Canyon off U.S. Highway 120 south of Thermopolis.
Photos courtesy of the Wyoming State Geological Survey.

(Continued on Page 13)

Geology of Boysen State Park

(Continued from Page 12)

exposed along the Boysen fault near the entrance to the southernmost tunnel on U.S. Highway 20 in Wind River Canyon.

Displacement along the Boysen fault and erosion by the Wind River exposed what is known to geologists as the Great Unconformity. In Wind River Canyon, the Great Unconformity represents more than a 2-billion-year gap in the geologic record; this feature is common in the western United States and can be observed in a few other Wyoming state parks. The Great Unconformity is visible at the southern end of Wind River Canyon, where the Precambrian igneous and metamorphic rocks (formed and metamorphosed between 2.9 billion and 2.7 billion years ago) are overlain by the Cambrian Flathead Sandstone (550 million years old; shown on map as part of Mesozoic–Paleozoic units, undivided), which was deposited in an ancient sea and in shallow rivers.

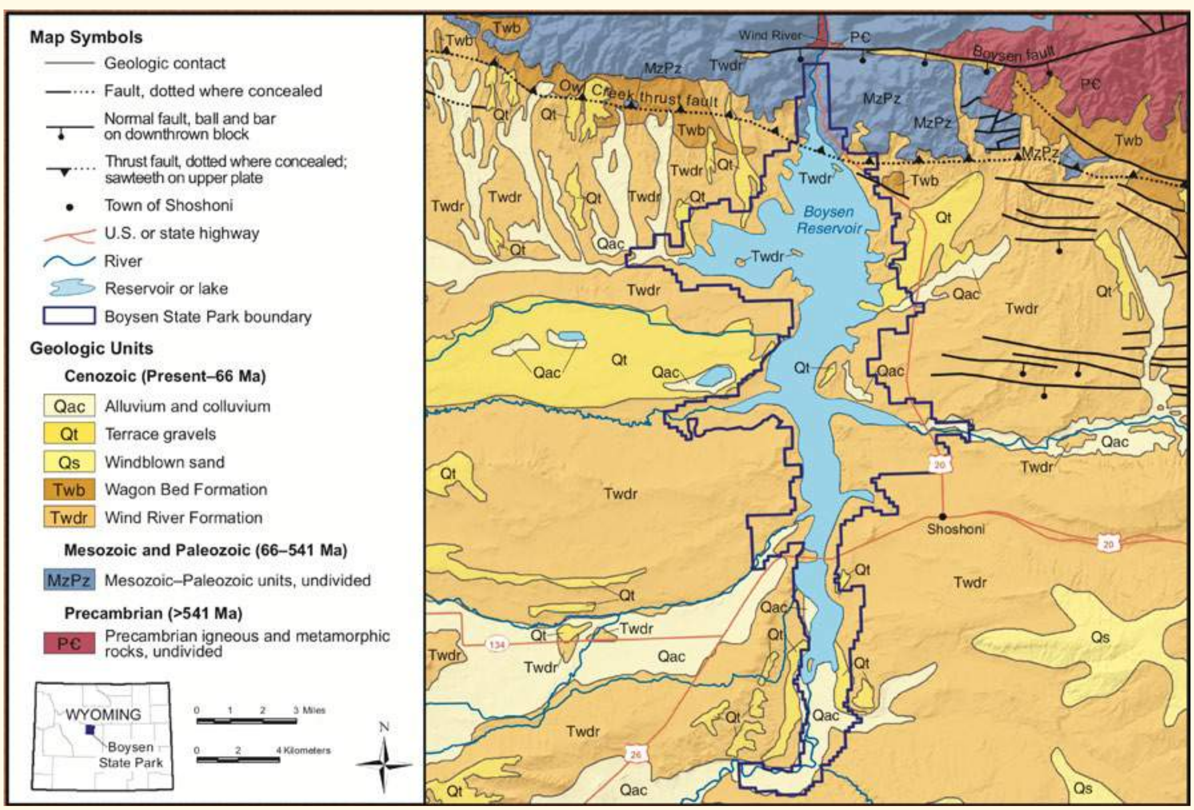
The two most prominent cliff-forming units in the upper Wind River Canyon are the marine shelf deposits of the Ordovician Bighorn Dolomite (450–446 million years old) and the shallow marine shelf deposits of the Mississippian Madison Limestone (357–345 million years old).

HYDROGEOLOGY

Exposure of the Eocene Wind River Formation in Boysen State Park.

Boysen Dam, a 220-foot-tall earth-fill dam, holds back the water of the Wind River that forms Boysen Reservoir. The present-day dam was constructed between 1946 and 1951 at the head of Wind River Canyon, slightly upriver from the original dam built by Asmus Boysen in 1908.

The reservoir is designed to hold 802,000 acre-feet (1 acre foot=326,000 gallons) of water. Most of the water stored in the reservoir originates as snowpack at higher elevations



Geologic map of Boysen State Park and the surrounding area. Ages of rocks are in millions of years (Ma).

(Continued on Page 14)

Geology of Boysen State Park

(Continued from Page 13)

in surrounding mountains. In fact, one of the reservoir's critical functions is to regulate snowmelt flows from these mountain ranges during high snowpack years to prevent flooding in downstream communities such as Thermopolis, Worland, and Greybull. Additionally, the reservoir is a source of municipal water for Thermopolis and provides irrigation water storage for regional agricultural lands. Hydroelectric power generated at the dam is connected to transmission lines that distribute electricity across the area.

The water stored in Boysen Reservoir and aquifers in the surrounding area form an integrated surface water and groundwater system.

Reservoir water infiltrates into the aquifers through fractures in aquifer rocks and through porous voids between individual mineral grains.

However, when water levels are low in the reservoir, some groundwater stored in the aquifers flows back into Boysen Reservoir as springs. Groundwater also discharges from springs located along the base of the Owl Creek Mountains to feed small creeks that flow directly into Boysen Reservoir. Springflows are highest for a few weeks after snowmelt and then decrease. By mid-summer, flows from these springs may be reduced to a trickle or dry up completely.

View of Precambrian rocks exposed along the trace of the Boysen fault at the southernmost tunnel in Wind River Canyon.

For more information, visit: wyoparks.state.wy.us/index.php/places-to-go/boysen

Wyoming State Geological Survey • P.O. Box 1347 Laramie, WY 82073-1347

www.wsgs.wyo.gov • phone: (307) 766-2286 • email: wsgs-info@wyo.gov

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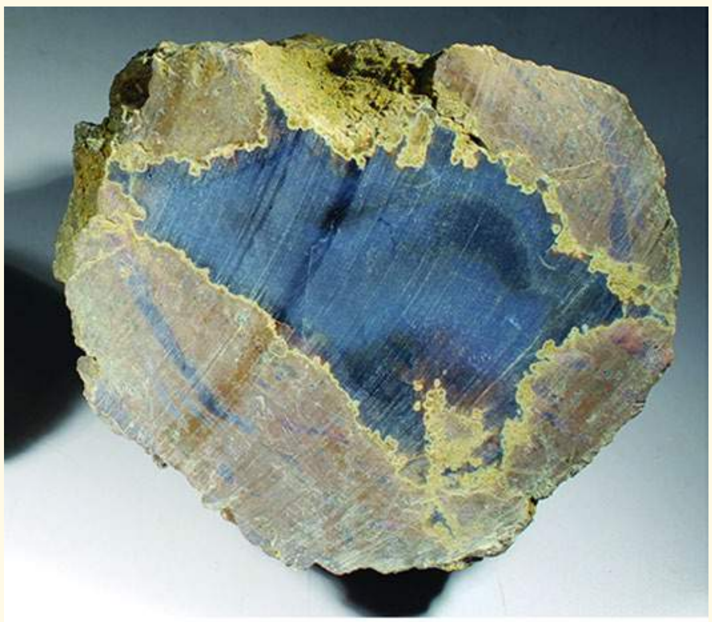
How to evaluate and cut thundereggs

How are Thundereggs Formed?

A thunderegg (or thunder egg) is a nodule-like rock, similar to a filled geode , that is formed within rhyolitic volcanic ash layers. Thundereggs are rough spheres, most about the size of a baseball though they can range from a little more than a centimeter to over a meter across. The outer covering of thundereggs is usually made up of chalcedony which may become cracked by water expansion. These cracks may allow minerals such as quartz, jasper, calcite, gypsum, agate, or opal to be deposited internally. Thundereggs usually look like ordinary rocks (but usually have cracked ridges on the outside). But slicing them in half and polishing them may reveal intricate patterns and colors.



• The minerals inside of thundereggs have been transported there while dissolved in water. The water picks up the minerals from surrounding igneous volcanic rock structures and deposits them into the hollow space that will form a thunderegg. Given enough time, the minerals will crystallize on the inside surface of the hollow egg. Different minerals contained in this solution will create different colored layers inside the egg.

•The formation and position of minerals deposited within a thunderegg is dependent on gravity. Guessing what is on the inside is made much easier by knowing the original position of the thunderegg because the most solid deposition of minerals will be on the bottom of the thunderegg. Therefore if thundereggs are collected from the host igneous rock, be certain to mark its original position as to top and bottom.

• If thundereggs are not collected directly from the original igneous rock layer in which they were formed and therefore are unmarked as to their original position, then another method may be used to determine where the position of the heaviest and most solid part of the thunderegg is located. In this case, try to find the center of gravity of the thunderegg by setting it on a flat smooth surface. Turn the thunderegg to different positions to determine if it has a tendency to roll in a certain direction. Remember that the heaver portion of the rock will end up at the bottom if it can freely roll and contains the most solid mineral deposits.

How to Cut Thundereggs

Thundereggs usually form internal layers of minerals. This layering makes it likely that, when hit with a chisel, the thunderegg will break along the layers rather than across the middle. For this reason, a diamond blade saw with a blade diameter of at least three times the diameter of the egg you are cutting should be used.

Because thundereggs are mostly round, the saw should also have a vise system to securely hold the thunderegg as it is being cut. The following information should help to determine how to cut individual thundereggs to create the best view of the internal thunderegg minerals.

• Not all thundereggs are created equal, at least when it comes to the orientation and kind of minerals inside. Also, the amount of water that was initially inside the thunderegg may determine the number and extent of the exterior cracks/ridges. If this internal water becomes heated by rocks that surround it, the water may be changed to steam which creates enough pressure to crack the outside of the thunderegg, forming the external ridges.

• If only two or three ridges are found and they are all at the top, then the silicon-saturated water which enters later will collect at the bottom.

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Evaluate and cut thundereggs

(Continued from Page 13)

Thundereggs usually look like ordinary rocks, but usually have cracked ridges on the outside.

• If there are many ridges found and they are all over the stone, then it will form symmetrically, built around a central air gap.

• If there are too many ridges to accurately guess the steam's path, this is classified as a thunderegg with "flow bands." Flow bands are ridges all facing the same direction.

Use the previous information in Part B and the following listed rules to decide how to cut a thunderegg in half or to slab it:

• Larger areas on the outside covering of a thunderegg with few ridges usually correspond to areas of larger layers of minerals.

• Cutting perpendicular (90 degrees) to the layer structure will show off the internal minerals best.

• It is recommended to cut across the air pockets.

Adapted References:

1. *How to Cut & Polish Thundereggs* https:// howtofindrocks.com how-to-cut-and-polish-thundereggs/

2. *Wikipedia-Thunderegg* en.wikipedia.org/wiki/ Thunderegg

3. *Orienting and Cutting Thundereggs* https://forum.rocktumblinghobby.com/thread/ 66102/ orienting-cutting-thundereggs

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2020 RMFMS Awards Banquet

The Rocky Mountain Federation of Mineralogical Societies' 2020 convention was hosted by the Wyoming State Mineral and Gem Society and the Sublette County Rock Hounds in Marbleton, Wyoming, on June 19-21, 2020. The following awards were presented at the RMFMS banquet:

• **RMFMS 2020 Honorary Award — Wayne Sutherland**

Wayne Sutherland was nominated by the Wyoming State Mineral and Gem Society Board to the RMFMS for consideration to receive the RMFMS 2020 Honorary Award. It was with great honor that the RMFMS approved our nomination. Wayne was honored at the RMFMS Banquet .

Wayne Sutherland has gone above and beyond his job at the Wyoming State Geological Survey to benefit Wyoming rock hounds. For many years, Wayne has shared his earth science knowledge with Wyoming residents around the state by providing educational programs to Wyoming rock clubs, school students, and at Wyoming Mineral and Gem Shows., He is a real asset to the Wyoming State Clubs by being available to answer questions and to provide educational materials. Wayne has also judged display cases and provided table displays of Wyoming Geological Survey publications at many Wyoming Mineral and Gem shows. Wayne wants to thank all the rock hounds in Wyoming for being so great about bringing him information and sharing their finds with him. Wayne was honored by the WSMGS as a "Wyoming Rockstar" and featured in the Jade State Newsletter (Volume 2018-Issue #-page 14). See wsmgs.org

Sutherland has worked more than 40 years as a geologist for private companies and government agencies in Wyoming, Montana, and Utah. His training and experiences include: gold and other metals, diamonds,

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2020 RMFMS Awards Banquet

(Continued from Page 16)

gemstones and lapidary materials, coal, oil and gas, uranium, industrial minerals, mining claim evaluation, and federal mineral regulations.

In the last four decades, Sutherland has been all over the map, Wyoming map that is, studying the state's geology and geologic features. When asked to pick his favorite, he replies, "The best geological places or features in Wyoming include a variety of locations where we have just enough information to discern a geological puzzle, but not enough information to solve it without serious on-the-ground investigation."

He has recently worked with Professor Dr Kevin Chamberlain to find modules of pre-Cambrian within the Green River basin so it can be correlated with other Precambrian in other regions of the world. The best sources of the nodules are in volcanic deposits such as within the Lucite Hills. His ongoing projects are investigating the occurence of Wyoming jade, which he hopes to publish soon, and an internet program of Wyoming mine locations and their associated minerals.

Sutherland's draw to geology started in childhood when he would ask his next door neighbor about what lies beneath the ground. "As I grew up, I would pick up interesting rocks, mostly in the Medicine Bow Mountains," he explains. "When I entered college, my first introductory geology class at the University of Wyoming got me hooked. Classes, lectures, and field trips brought to life a four-dimensional appreciation for Wyoming's geology."

Sutherland earned his bachelor's degree in geology and his master's degree in geomorphology from UW. Mentors while attending UW include Brainerd "Nip" Mears, Sam Knight, Don Boyd, Don Blackstone, Scott Smithson, Bob Houston, Ron Parker, and Ron Marrs.

Being a geologist holds numerous attractions. Sutherland says for him, it is the public outreach opportunities and the field work that he most enjoys. "Field work, site investigations and mapping, combine physical exercise with geologic conundrums. My assistant one year figured that we had walked over 100 miles in the course of field work; good exercise in the fresh air," he explains. "The exercise is needed to collect data and compile map elements. Interpretation of the data, in combination with its geologic/geographic elements, provides a mental picture of a particular geologic setting. Reduction of the mental picture contributes to a finished map and written report explaining the geology and mineralization. Completion of maps and investigations is satisfying.

The WSGS will say farewell to one of its longtime geologists at the end of December 2020. Gemstones, metals, and economic geologist, Wayne Sutherland, is retiring after several years with the agency. "Wayne's knowledge and enthusiasm truly will be missed at the survey," says WSGS director, Dr. Erin Campbell. "The breadth of information he has about Wyoming geology, as well as the depth of his expertise in minerals, cannot be replaced. We wish him all the best in retirement."

In the 1970s, his responsibilities ranged from compiling coal data to investigating caves in Wyoming. Toward the end of the 1980s, he worked with stream sediment sampling in search of kimberlites and with various metals and gemstones. In the late 1990s through mid-2000s, Sutherland held different contract positions, primarily in metals and gemstones, and in geologic mapping. After a few years as a part-time employee, he was hired full time at the WSGS.

"When I retire, I look forward to spending more time with my wife, Judy," Sutherland says. "I also plan on a variety of travel, hobbies, and home projects. I will always connect with geology and will maintain contact with many of the people I have met during the course of my job."

At this time in Wayne Sutherland's the Wyoming State Mineral and Gem Society and its affiliated clubs would like to invite Wayne and Judy to continue exploring Wyoming's rocks with us. Find us on our website: wsmgs.org.

- **RMFMS 2020 Student Scholarship Award — Greg Stark and Adam Trzinski**

As a RMFMS Honorary Award recipient, Wayne Sutherland directed the selection of two students from the University of Wyoming to each receive a $4,000 scholarship award that is funded by the American Federation of Mineralogical Societies Scholarship Foundation. In order to be eligible for this scholarship, the scholarship recipients must be enrolled during the 2020-2021 school year as graduate students majoring in one of the Earth Science disciplines. The students selected were Greg Stark and Adam Trzinski.

Adam Trzinski is enrolled in the PhD program in geology at the University of Wyoming.. His dissertation project is "Evaluating a Mechanism for an Orogenic Plateau in the Southern U.S. Cordillera." Greg Stark is a PhD student whose interest is the Jemez volcanic field, its derivation and geochemistry. His contact information is: Greg Stark, Email gstark2@uwyo.edu, University of Wyoming Department of Geology and Geophysics, Dept. 3006, 1000 E. University Avenue, Laramie, WY 82071.

RMFMS Scholarship Committee report

January 18, 2021

Thus far, two Rocky Mountain Federation clubs and the RMFMS itself have contributed to the AFMS Scholarship Foundation for the fiscal year of Nov. 1, 2020 through October 31, 2021. I sincerely wish to thank both of the clubs which have contributed to the Scholarship Foundation and of course the RMFMS.

The clubs, the amount they contributed, and the percentage to which that brings them are listed below. A percentage of 2500% would mean the equivalent of the club donating $1/member for 25 years.

RMFMS — $4,139.65

Tulsa Rock & Mineral Society** — $421.00 4700%

Wichita Gem & Mineral Society** — $ 50.00 5600%

Total Donations — $4,610.65

Some of the donations from the Tulsa club were made in memory of Claudine Ruth Elmore, Bob Hicks, Jack Hill, and Billie Marie Need.

The donation from the Wichita club was made in memory of Steven Hardin.

I hope that we will have contributions from several other clubs this year. Remember that through the AFMS Scholarship Foundation, our RMFMS is able to award two $4000 scholarships each year to graduate students majoring in the Earth Sciences. These donations are also an excellent way to honor members who have passed away.

Our Honorary RMFMS Scholarship Awardee this year is Dr. Paul D. Brooks a professor in the Department of Geology/Geophysics at the University of Utah. He was nominated by the Wasatch Gem & Mineral Society of Riverton/Salt Lake City, Utah. Dr. Brooks will select two outstanding Geology graduate students to receive our scholarships this year.

Respectfully submitted,

Richard Jaeger, Scholarship Chairman

AFMS Endowment Fund

I am the Rocky Mountain Federation Regional Chairman for the AFMS Endowment Fund. Cheryl Neary, a member of the Eastern Federation, is the AFMS Endowment Fund Chair and also the AFMS Central Office Administrator.

Basically, this is a raffle drawing with tickets being sold at $5 each or five tickets for $20. The drawing will be held at the RMFMS/AFMS Convention in Wyoming in June.

People from around the American Federation donate prizes for the raffle – they may be jewelry, crystals, minerals, fossils, books, or other items, the value of which range generally from $75 to $200. Last year because the AFMS Show in Knoxville, TN was cancelled, there was no drawing.

As items are donated, pictures of them will appear in the AFMS Newsletter and on the American Federation Website <amfed.org>. There are generally around 30 items.

This is a major way to financially support the American Federation's efforts on behalf of our hobby.

Currently the funds go towards the Junior Rockhound Program, Judges Training, and preparing Programs for distribution to Regional Federations which can be used by individual clubs. Over $4,000 was raised last year. Cheryl requests that the checks be sent to the regional chairs so that we may issue tickets and have a record of who has entered. Checks should be made payable to the "AFMS Endowment Fund". We then forward those checks to Pat LaRue, the AFMS Treasurer. I will fill out the proper number of tickets for each contribution, send the stubs to the donating individual, and get the tickets to the RMFMS/AFMS Show in Big Piney, Wyoming from June 17-20, to be put into the RMFMS bag.

There will be at least one general prize ticket, maybe two or three, drawn from each of the bags for the seven regional federations. After that, all tickets will be dumped into one bag, and further drawings will take place until all the prizes have been awarded.

I hope that many of you will participate and hopefully be winners in Wyoming; but you need not be present to win. I would also be happy to accept any donated prizes for the raffle or they could be sent directly to Cheryl Neary; the more prizes, the more winners, and hopefully, more money raised. Cheryl's address is: 42 Jefferson Ave., Patchogue, NY 11772. I am donating an ammonite fossil from Madagascar myself and my wife Linda is donating a gemstone necklace.

My contact information is provided below. Please share this information with your club members and thanks for your consideration.

Richard D. Jaeger
3515 E. 88th St.
Tulsa, OK 74137-2602
918-481-0249
RjgrSci@aol.com

Club News

Cody 59ers

The Cody 59ers elected officers through an email vote in December. They are: Greg Jones, President; John Severeide, Vice President; Nella Flurkey, Secretary; Audrey Smith, Treasurer.

Because there were limited meetings last year, the club voted to forego collecting dues from members who paid their dues in 2020. New members joining in 2021 will pay dues as usual.

The 59ers began meeting again in February, with a show-ant-tell program. Members were invited to bring tumbled, cut and polished rocks that had been made into jewelry or art.

Club members also discussed the field trip schedule for 2021.

In March, the club met for a program by Jamie Lindemann, who spoke about variscite discoveries in Park County, Wyoming. Variscite is a gemstone similar to turquoise.

Sublette County Rock Hounds

The Sublette County Rock Hound Club's (SCRH) first meeting of 2021 took place on Saturday, March 13, at the Sublette County Fairgrounds, with 41 members attending. The monthly business meeting included preparations for the annual gem and mineral show scheduled for June 18-20 at the Sublette County Fairgrounds' Event Center.

This year, the club is hosting annual conventions for the American Federation of Mineralogical Societies and the Rocky Mountain Federation of Mineralogical Societies. On Friday, June 18, and Saturday, June 19, the show is open from 9 a.m. to 4 p.m. Admission is $2 for adults; kids get in free.

Last year's big event took place with COVID precautions and was very successful, with families and rockhounds coming from across the state and country to enjoy meetings, demonstrations, field trips, displays, concessions, dealers and fun activities.

Following the business meeting, David Freeman of Rock Springs, Wyoming, offered a presentation about glacial history in Western Wyoming and types of jade found in Wyoming, including rocks commonly mistaken for nephrite jade.

Other items on the agenda were accepting nominations from the membership for the annual Rock Hound of the Year (R.O. Y.) award for an adult and junior member. These nominations are presented to the Wyoming State Mineral and Gem Society (WSMGS) for review. The State Rock Hound award is selected from among submissions from all of the Wyoming clubs by an unbiased committee.

The awards will be given at the annual WSMGS meeting, which will be held this year in Casper at the annual Natrona County Rock Hounds show, July 9-11. The annual WSMGS show travels among the seven state clubs.

The club's next meeting is Saturday, April 17, at 1 p.m. at the fairgrounds Event Center. New members are always welcome.

For more information about the cub and its 2021 Sublette County Rock Hounds' Gem and Mineral Show, visit the Facebook page or email jimgray@wyoming.com.

This 20-inch by 16-inch Amethyst Cathedral is the grand prize for the joint annual convention of the American Federation of Mineralogical Societies and the Rocky Mountain Federation of Mineralogical Societies, hosted by the Sublette County Rock Club on June 18-20.

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2021 Rock Show Flyers

2021 Rock Show Flyers

Sublette County Rock Hounds'

Gem & Mineral Show 2021

Hosting the annual CONVENTIONS of the

American Federation of Mineralogical Societies

Rocky Mountain Federation of Mineralogical Societies

June 18th, 19th, & 20th

at the Sublette County Fairgrounds
10937 Hwy 189,
Big Piney, Wyoming

Friday & Saturday 9-5, Sunday 9-4

Dealers, demonstrators, exhibits, field trips, fluorescent mineral display, kids' activities, food concession & more!

Admission: $2.00 adults, kids free

Contact: jimgray@wyoming.com or schafma1@hotmail.com

2021 Rock Show Flyers

NCRC presents the 73rd Annual

GEM & MINERAL SHOW July 9-11, 2021

2021 Annual *WYOMING STATE MINERAL & GEM SOCIETY* Show

Fri & Sat 9-5 • Sun 9-4

Actual Raffle Item

Admission $3
under 12 free

Ramkota Hotel
800 N Poplar
Casper WY

Raffle: Amethyst Cathedral, hunk of Wyoming Jade, hunk of Olive Jade and much more
Silent Auctions: WY rocks in the rough
Door Prizes: $10 rockhound bucks
Demonstrations: Cabbing Demonstration

Contact: Mac Goss 307.439.9873 macogre13@yahoo.com

WSMGS Rock Clubs

Riverton Mineral & Gem Society

P.O. Box 1904
Riverton, WY 82501

rivertonmgs@wsmgs.org
www.RivertonMGS.com

Meets 2nd Mon. 7 p.m.
(Jan.-May, Aug.-Nov.)
Senior Center, 303 E. Lincoln, Riverton

President: .... Stan Grove
Vice-President: .... Open
Treasurer: .... Al Zelnak
Secretary: ....Holly Skinner
JSN .... Open
Historian.................................... Open
Field Trips .... Ted Knowles

Cheyenne Mineral & Gem Society

P.O. Box 21412
Cheyenne, WY 82003

cheyennemgs@wsmgs.org

Meet 2nd Wed. 7 p.m. (August-May)
IBEW Union Building
810 Fremont Street-Cheyenne

President: .... Open
Vice President .... Open
Treasurer: .... Jan Shively
Field Trip..................... Mark Shivley

Natrona County Rockhounds

P.O. Box 123,
Casper, WY 82644

natronarockhounds@wsmgs.org

Meets 1st Monday 7 p.m. (April-Dec)
Shop Open 6-8 p.m. Tue & Fri at
Clubhouse, 5211 Rambler, Mills

President: ....Martin "Mac" Goss
Vice-President: .... John Hines
Treasurer: .... Kenny Platte
Secretary: ....Martin "Mac" Goss

Cody Fifty-Niners Rock Club

P.O. Box 1251
Cody WY 82414

cody59ers@wsmgs.org
www.Cody59ers.com

Meets 4th Thursday (Sept-May) 6:30 p.m.
Park County Courthouse, EOC room,
1002 Sheridan Ave., Cody

President: ....Greg Jones
Vice-President: .... John Severeide
Treasurer: .... Aubrey Smith
Secretary ....Janet Lorher
Historian: .... Stan Strike
Field Trips ....Nella Flurkey

Sublette County Rock Hounds Club

P.O. Box 1351
Big Piney, WY 83113

subletterockhounds@wsmgs.org

Meets 1 p.m. 3rd Saturday (March-Dec)
The Bench Grill
415 Winkleman, Marbleton

President: .... Jim Gray
Vice-President: .... Mike Schaffer
Treasurer: .... Leane Gray
Secretary: .... Deb Jess

Shoshone Rock Club

P.O. Box 256,
Powell, WY 82435

shoshonerockclub@wsmgs.org

Meets 2nd Tuesday 7 p.m.
Powell Library
317 E. Third St., Powell

President: .... Dorine Strom
Vice-President: .... Mary Vogel
Treasurer: .... Cheryl Thomas
Secretary: ....Linda Thomas
JSN: .... Ilene Olson
Historian: ....Linna Beebe
Field Trips .... Dorine Strom

Rex Young Rock Club

112 East 3rd
Lingle, WY 82223

rexyoungrockclub@wsmgs.org

Meets 2nd Wednesday 7:00 p.m.
Senior Center
216 E. 19th Ave., Torrington

President: .... Kim Nielsen
Vice-President: .... Ed Verplancke
Treasurer: ....Helen Vogel
Secretary: ....Joyce Trowbridge
JSN: ....Joyce Trowbridge
Historian: ....Joyce Trowbridge
.... Dale Tikalski

Northeast Wyoming Rockhounds

2107C N. Hwy 14-16
Gillette WY 82716

newyrockhounds@wsmgs.org

Meets odd # months
Check email for dates

President: ....Jeff Hulings
Vice-President: .... Dennis Brown
Treasurer: ....Beth Raab
Secretary: .... Gary Haptonstall