MT ST HELENS, UNITED STATES OF AMERICA

Following its spectacular eruption on May 18, 1980, Mt St Helens has become the world's most studied volcano. The US Geological Survey has set up a permanent observatory on Johnston Ridge, located 5 miles (8 km) from the volcano. It is named for geologist David Johnston who lost his life on the ridge that fateful morning.

OPPOSITE The lava dome in the blown-out crater of Mt St Helens releases volcanic gases. Dormant since 1857, the force of the 1980 eruption blasted the top off the mountain, reducing its height from 9,647 feet (2,950 m) to 8,335 feet (2,549 m).

ABOVE Spirit Lake was littered with dead trees blasted by the 1980 eruption of Mt St Helens. The eruption created the largest recorded landslide, which thrust the lake's water into 600-foot-high (183-m) waves and wiped out an entire forest.

The status of the mountain is constantly being monitored via a network of video cameras, seismometers, and other instruments covering its slopes, and its explosive fury is by no means spent. Minute earthquakes signify the movement of new magma, while swelling of the mountain indicates pressure buildup within its subterranean magma chambers, heralding the possibility of another eruption. These changes in shape of the volcano are mapped continuously on centimeter-scale accuracy by Earth-orbiting satellites, so hazards can be assessed well before they pose a threat to life.

THE YOUNGEST, MOST ACTIVE VOLCANO IN THE USA

Louwala–Clough or "smoking peak" was the name for Mt St Helens used by the Pacific Northwest Native Americans. Its cone has grown up entirely within the last 2,200 years and the oldest volcanic ash deposits date back only 40,000 years, making it the youngest major volcano in the Cascade Ranges. Apart from intermittent activity between 1831 and 1857, the volcano had been peaceful. Visitors came by the thousands, lured by the mountain's reputation of tranquility, to fish in the clear-water lakes or hike on the forested slopes of its graceful conical peak.

However, all of that changed in May 1980 when the upper 1,300 feet (397 m) of the mountain's summit was blown away, leaving a massive horseshoe-shaped crater. The sudden pressure release due to an avalanche allowed superheated groundwater around the volcano's magma chamber to flash to steam. It blasted laterally northward, out of the avalanche scar, and formed a hot, destructive pyroclastic surge of ash and debris. Immediately north of the volcano, tens of thousands of acres (hectares) of productive forest were destroyed. Giant trees were uprooted and laid down like matchsticks, while at greater distances they were stripped bare. Within minutes, an enormous column of gas and ash rose from the summit accompanied by massive lightning bolts. The ash column rose some 12 miles (19 km) into the atmosphere before flattening into a giant umbrella shape. Then it collapsed on itself, raining down huge quantities of ash, pumice, and rocks. The eruption lasted nine hours.

CURRENT STATUS OF THE MOUNTAIN

Mt St Helens is currently, in 2007, on Alert Level 2 (Aviation Code: Orange). A new lava dome is slowly growing within the volcano's crater, accompanied by minor seismic activity and emissions of ash, steam, and volcanic gases. All of the other Cascade Range volcanoes are presently at background levels of seismic activity and pose no immediate threat.

FAR-REACHING HAZARDS

The enormous ash cloud was pushed quickly eastward over the United States by strong high-level winds, blocking the morning sun. It turned day into night, grounding all forms of transport and forcing people to wear masks. Fine airborne ash took three days to cross the continent and 17 days to circle the globe.

In total, some 57 people lost their lives, including scientists working on the mountain, campers, a few logging company workers, and Harry Truman, a man who stubbornly refused to leave his lodge on Spirit Lake. The death toll might have been much higher were it not for the US Geological Survey's 20-mile (32-km) cordon around the volcano that restricted access to all but essential personnel. As well as the human toll, it is estimated that the eruption killed 5,000 black-tailed deer, 1,500 elk, 200 black bears, plus unknown numbers of mountain lions, bobcats, rodents, birds, fish, and insects. Complete rebuilding of the local food chain may take many decades.

It is not clear whether Mt St Helens will blow itself apart in another major eruption in the near future, or sometime later, after it has rebuilt a new majestic conical top.

Missouri and Mississippi Rivers, North America

The Missouri and Mississippi rivers share the largest watershed in North America, and, by world standards, it is third only to the Amazon River in South America and the Congo River in Africa. The combined length of these two North American rivers—over 4,000 miles (6,400 km)—makes them the world's fourth longest river system.

BELOW The Mississippi River begins broadening into the low-lying backwaters and marshes of the Upper Mississippi River National Wildlife Refuge at Black River Delta. This park was created as a refuge for local waterbirds to breed, and is a prime habitat for many migratory birds.

The lengths of the Missouri and Mississippi are remarkably similar, and incredibly difficult to determine exactly because of the engineering of channels to make the rivers more accessible to navigation and because of the natural processes, such as flooding, that change channel courses. However, some would argue that the Missouri when measured at 2,341 miles (3,767 km) is longer than the Mississippi at 2,320 miles (3,705 km).

Mississippi is derived from the old Native American Ojibwe word, *misi-ziibi,* meaning "great river," while *Missouri* is a Missouri Indian name meaning "town of large canoes."

THE VAST MISSISSIPPI WATERSHED

The Mississippi Basin or watershed drains a funnel-shaped area between the highlands of the Rocky Mountains to the west and the Appalachian Mountains to the east; an area well over 1,200,000 square miles (3 million km^2). This is over 40 percent of the area of continental USA, and takes in 31 states and two Canadian provinces. The source waters of the Mississippi come from a number of small streams that flow into Lake Itasca—a lake of glacial origin—some 1,475 feet (450 m) above sea level in Clearwater County, northwestern Minnesota. It drops to 725 feet (220 m) at St Anthony Falls in Minneapolis—the only waterfall along its length.

From its source in Montana, the Missouri River flows into the Mississippi River near St Louis in Missouri. The lower river is characterized by extensive meandering channels that twist and turn through the broad alluvial plain, which varies in width from 25 to 125 miles (40 to 200 km). Many loops of the meanders have been cut to form oxbow lakes and these, together with extensive marshes, indicate remnants of the river's former channels. The Mississippi River then continues its journey south to Louisiana on the Gulf of Mexico, where it forms one of the largest bird's-foot deltas in the world.

TAMING A RIVER SYSTEM

Although there have been many tremendous natural changes to the course and nature of the Missouri–Mississippi River system in the recent geologic past, the most significant changes have been those made by humans in those relatively few years since early settlement. The rivers have been kept open for commercial navigation and floods under control by extensive engineering projects.

Human influence has impacted greatly on the river system, and it is said that only 1 percent of the length of the Missouri remains uncontrolled by human activity. Currently, there are efforts being made to reclaim some of the altered habitats, such as wetlands, and return them to their former natural state.

FROM PRECAMBRIAN RIFTING TO ICE AGE

Geologically, the Mississippi Basin is a vast syncline that funnels down toward the Gulf of Mexico. It was formed through rifting during extensive Precambrian Era tectonic activity some 750 million years ago and is the underlying structure of the Mississippi embayment, which filled when sea levels rose during Cretaceous Period tectonic activity (around 100 million years ago). During this period, a subsequent fall in sea levels caused the ocean to retreat, leaving the embayment as the valley of the Mississippi. Large amounts of sediment were deposited by the river as it flowed toward the Gulf of Mexico.

The many rapid sea level changes during the Pleistocene Epoch glaciations—between 1.6 million and 10,000 years ago—together with abundant meltwater from the glaciers—resulted in the Mississippi forming deep valleys and channels when the sea levels were at their lowest and river terraces at their highest.

From the time of the initial rifting, the syncline continued to subside and fill with massive amounts of sediments to a present basin depth of several miles. These are covered with a thick sequence of Quaternary Period deposits that blanket the many ancient channels and other valley structures.

Investigations show there have been many changes in river channel numbers and courses since the time of its inception. Some changes in channel direction have been caused by earthquakes along the New Madrid Fault Zone, which is associated with the original rifting. Present-day seismic activity along these faults has caused some of the largest earthquakes ever recorded in North America, such as those occurring in the early 1800s.

On the lower Mississippi Delta, channel switching causes changes to course direction in cycles that occur roughly every 1,000 years. As the sediments are moved further toward the sea, the delta advances into the Gulf of Mexico, moving the coastline seaward from 15 to 50 miles (24 to 80 km) over the past 5,000 years.

A DIVERSITY OF RIVER LIFE

The Mississippi River has a vast range of habitats and an extensive biodiversity. Extraordinary numbers of fish, amphibians, reptiles, and invertebrates are found in the many unique habitats associated with the wetlands, open water, and floodplains. Some species are relicts of the glacial environments of the Pleistocene Epoch.

The biota of the river ecosystem is greatly threatened by farming activities, including land clearing, intense cultivation, and pollution through nutrients and pesticides. Wastewater and sediment from urban development pose further threats. These are apart from the engineering of the major hydrological modifications that have destroyed habitats from the time of white settlement.

LEFT The Mississippi River Delta drains into the Gulf of Mexico. This satellite image shows the vast quantities of sediment—topsoil, sand, and vegetation—that were deposited along the shores of Louisiana and into the gulf following a big storm.

BELOW A group of midland painted turtles (*Chrysemys picta marginata*) bask on a log with an American alligator (*Alligator mississippiensis*) in the lower reaches of the Mississippi River.

Missouri and Mississippi Rivers, North America

Victoria Falls, Africa

Mosi-oa-Tunya—or "the smoke that thunders"—is the indigenous name for Victoria Falls, which form part of the border between southern Zambia and northwestern Zimbabwe in southern Africa. In 1855, David Livingstone—the first European to sight the falls—named them in honor of Queen Victoria.

BELOW Tourists in Zimbabwe viewing Victoria Falls from the top of the gorge are continually showered by mist from the spray that rises up from the vast volume of water that passes over the falls every minute.

Victoria Falls is among the most spectacular falls in the world, and is the world's greatest sheet of falling water. The Zambezi River is roughly 1 mile (1.6 km) wide at the point where it plunges from a height of 300 feet (90 m) deafeningly down a series of basalt gorges, raising a shimmering mist that can be seen more than 20 miles (30 km) away.

Rainbows add to the splendor when they materialize in the mist. The falls are made all the more spectacular by the channelling of over 300,000 cubic feet (9,000 m^3) per second of water into the narrow 100-foot (30 m) wide Batoka Gorge. It is possible to view the falls from the other side of the narrow gorge directly opposite.

NATIONAL PARKS AND WILDLIFE

The falls are part of two national parks on either side of the Zambezi River—Mosi-oa-Tunya National Park in Zambia and Victoria Falls National Park in Zimbabwe. Both are relatively small, covering areas of 25 square miles (65 km^2) and 9 square miles (23 km^2) respectively and both were placed on the World Heritage List in 1989.

A riverine "rainforest" lies within the waterfall splash zone. Growing on sandy alluvium, this discontinuous forest relies on the plume of spray arising from the falls to supply moisture and create the high humidity necessary to maintain this fragile ecosystem. Tree species within this forest are many and include acacias, ebony, and the ivory palm and date palms.

In the parks around the falls are sizable populations of elephants, buffalo, and giraffes and a general abundance of other animals, including a large population of hippos. There are some 400 species of birds in the Victoria Falls region, and the gorges below the falls are a breeding site for the Taita falcon (*Falco fasciinucha*), Verreaux's eagle (*Aquila verreauxi*), and peregrine falcon (*Falco peregrinus*).

CULTURAL HERITAGE

In the area near Victoria Falls, various stone artifacts have been found. These have been identified as belonging to the hominid species, *Homo habilis*, from 3 million years ago. Stone tools indicate that there was prolonged occupation of the area in the Middle Stone Age 50,000 years ago, and weapons, adornments, and digging tools dated between 10,000 and 2,000 years ago point toward the presence of Late Stone Age hunter-gatherers. Farming communities more recently displaced these early inhabitants.

Victoria Falls is the physical boundary that distinguishes the regions of the upper and middle Zambezi River—with each river region populated by distinct fish species.

FRACTURES AND FISSURES

The Zambezi River flows for a considerable distance over a level sheet of basalt through a valley bounded by low and distant sandstone hills. Numerous tree-clad islands dot the course of the river, increasing in number in the approach to Victoria Falls, which marks a rough midway-point along the river's course.

Uplifting of a region known as the Makgadikgadi Pan some two million years ago caused the Zambezi River to cut through the basalt plateau along fractures that created east–west trending fissures. Over some many thousands of years, the falls have been receding upstream and relics of seven past waterfalls now form a series of sharply zigzagging gorges downstream from the falls. The Devil's Cataract in Zimbabwe is presently the start of a part that is now being cut back to form an eighth waterfall that will eventually leave the present crest high above the river in the canyon below.

At the end of the first gorge, the river has hollowed out a deep pool—called the Boiling Pot—that measures about 500 feet (150 m) across. The surface water of the Boiling Pot is smooth when the flow is low, but, as the flow over the falls increases, slow enormous eddies form in the churning water. From the Boiling Pot, the river channel turns sharply westward and enters the next of the zigzagging gorges that have walls around 400 feet (120 m) high.

ABOVE The flow of the Zambezi River into the falls can vary considerably depending on the climatic conditions at the time. During the middle of 2006, a severe drought caused the river to dry considerably and reduced its flow so significantly that the river braided into channels.

ABOVE LEFT A bloat of hippopotamuses (*Hippopotamus amphibius*) gathers in the Zambezi River. They have adapted to the harsh African sun by secreting a reddish orange pigment through their skin that has sunscreening properties. Curious evidence from 47-million-year-old whale fossils support a theory that whales are related to hippopotamuses.

MT ETNA, ITALY

Sicilians do not regard Mt Etna as being particularly dangerous, referring to it as their "good volcano." Thousands live on its flanks; its fertile volcanic soils are perfect for agriculture, with the mountain slopes a green patchwork of countless vineyards, olive groves, and orchards. Catania, Sicily's largest city, with its population of over 1 million, sprawls across the lower slopes of the volcano.

Despite its apparent tranquility, Mt Etna can be very destructive. It is Europe's largest and most famous volcano, with the longest historic record of eruptions. The first was recorded about 1500 BCE when a large explosion caused its eastern flank to catastrophically collapse in an enormous landslide. Diodore of Sicily described the event, which reads similarly to the well-known Mt St Helens eruption of 1980.

ABOVE A fiery new cone on Mt Etna glows in Sicily's night sky in 2002. For 24 days during the summer of 2002, Etna gave its most dazzling show in a decade. It again spouted lava fountains in May 2007 after a gash opened. It is the highest active volcano in Europe, reaching 10,910 feet (3,328 m).

RIGHT Being a highly active volcano, Mt Etna is one of 16 volcanoes around the world listed as a decade volcano. These are intensely active volcanoes, often near large populations, that have exhibited highly destructive eruptions in the past and are considered worthy of intensive study.

MT ETNA'S DESTRUCTIVE PAST

One of the most dramatic eruptions of Mt Etna began on March 11, 1669, when a fissure opened on the volcano's south flank. Activity slowly moved down the flank with the biggest vent opening up near the town of Nicolosi. Powerful explosions began to build the Mt Rossi cinder cone and exude voluminous lava. Sections of Nicolosi and nearby villages were quickly incinerated. Fortunately, most villagers had abandoned their homes because of increasingly strong earthquakes in the two months prior to the eruption. Lava flowed down the volcano's flank, overwhelming numerous hamlets, villages, and towns in its path. Refugees fled ahead of its advancing front to Catania and were housed there.

In early April, the lava reached the city wall on the western side of Catania and began piling up against it. The flows were initially deflected to the south by the wall and began filling the city's harbor. Lava kept rising until eventually, on April 30, the pressure grew too strong and a section of the wall collapsed allowing lava to enter the city. It destroyed monasteries and other buildings around the church of San Nicolò l'Arena. Residents rallied and quickly built walls across the roads leading down to the lower part of the city in an attempt to stop the flows. Although much destruction ensued in the upper part of the city, the strategy worked and widespread damage was avoided. The eruption finally ceased on June 11.

The most destructive eruption of the twentieth century began on November 2, 1929. Explosions and plumes began near the volcano's summit, propagating along opening fissures down the eastern flank. On November 4, the lowermost fissure opened and lava began pouring into a ravine above the town of Mascali. The next day there was an orderly evacuation of Mascali's 2,000 inhabitants, before the lava flow advanced slowly through the entire town, consuming its buildings and cultivated land. The cathedral was the last building to be buried. By November 7, Mascali was gone. The eruption stopped on November 20. No one was killed, and residents had time to save their lives and household goods, even removing roof tiles in front of the slowly advancing lava.

THE FUTURE OF MT ETNA

The volcano continues to be active with some of its more recent eruptions being quite explosive. Monitoring systems on the volcano, capable of tracking sub-surface movements of magma, now warn civil protection authorities days to months in advance of an impending eruption. Micro-earthquakes indicate that, since 1994, magma has been rising from a chamber 4 to 9 miles (6 to 15 km) beneath the volcano and is filling a shallower chamber 2 to 3 miles (3 to 5 km) below the surface. The buildup in pressure in the shallow storage area appears to have triggered the eruptions that took place in 2001 and 2002. Volcanologists are concerned that this explosive pattern of behavior will continue. Flank eruptions are occurring and are expected to continue at intervals ranging from one to three years, some of which might be much more voluminous and explosive than in the past.

LEFT Closeup of the sulfurous deposits found on Mt Etna. Steaming fumeroles on volcanoes release gases including noxious sulfur dioxide, which precipitates into sulfur deposits. Along with this gas, copious amounts of carbon dioxide are released that have altered the atmosphere for years following a major eruption.