FOREWORD

by **Wayne Ranney**

The Grand Canyon of the Colorado River is one of our planet's most compelling and recognizable landforms. Each year, nearly 4.5 million people stand in awe on the canyon's rim and gaze into one of the most colorful and spectacular panoramas that can be viewed from a single place (Fig 1). The canyon overwhelms the senses and inspires deep feelings within those who look into it. It is the rare individual who, upon seeing the Grand Canyon for the first time, does not ask, "How could this have formed?"

Humans have interacted with this deep gorge since prehistoric times, but we do not know how ancient people reacted upon first seeing the canyon's vast excavated space. We know they were here because of the cryptic evidence left behind in caves tucked into the canyon walls. Like us, they too must have been awed.

Old World Europeans did not arrive at the canyon until the year 1540, when Hopi Indian guides led a group of Spanish gold seekers from the Coronado Expedition to its South Rim. Because the canyon did not contain gold or other precious metals, the Spaniards moved on and the area lay mostly unvisited by European immigrants for more than three centuries. Not until the arrival of the first explorers in the mid-nineteenth century did the Grand Canyon penetrate the American consciousness, by way of various reports sent to Congress by the expedition leaders or the scientists who accompanied them.

In the exhilarating days of Western exploration, much of the American West was called the "Great American Desert." At that time, visions of earthly beauty were based exclusively upon the European ideal, honed in the Alps and rich with idyllic scenes of

Figure 1. The heart of the Grand Canyon from Mather Point. *Photo by Mike Buchheit.*

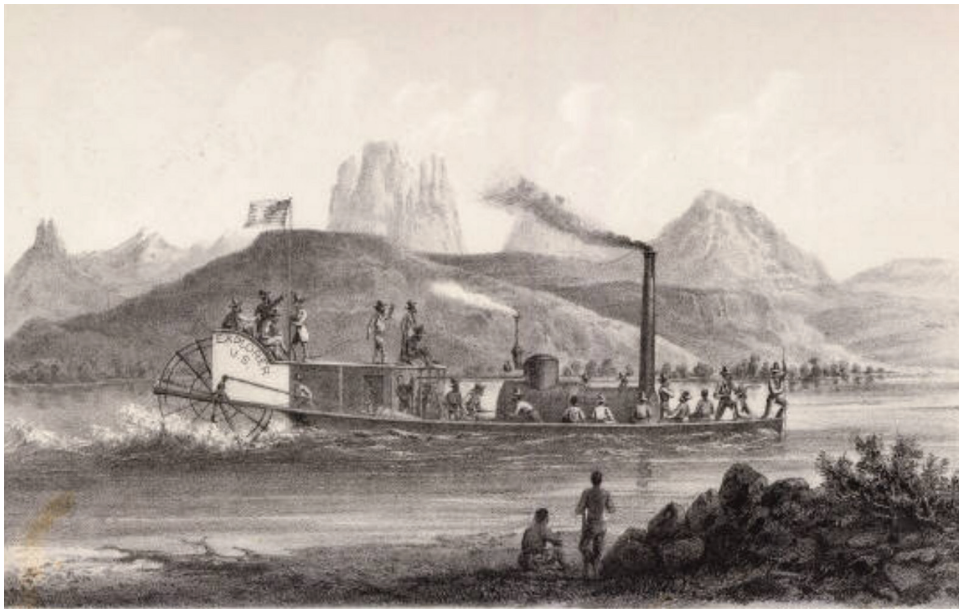

Figure 2. The steamship Explorer, the craft used by the Ives Expedition to travel up the Colorado River in the winter of 1857. *Courtesy of the Library of Congress.*

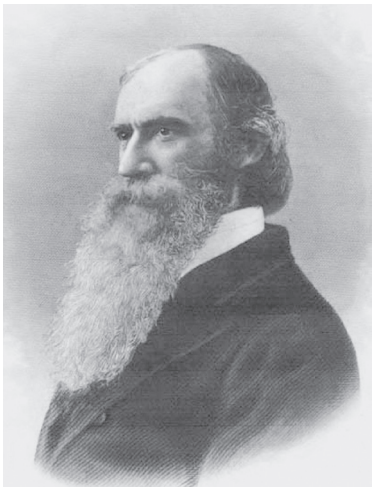

Figure 3. John Strong Newberry, first geologist to see the Grand Canyon. *Photo from the U.S. Geological Survey.*

glaciated mountains, clear-running streams, and the color green. Americans were largely repulsed by the vast, arid Western landscape and observed it only in passing as they crept along in their creaking wagons towards greener pastures in Oregon and California.

Ultimately, however, Manifest Destiny brought them face to face with the southern edge of the Colorado Plateau and the Grand Canyon, and it was not always an easy encounter. Hampered by the dry winter conditions in 1857 and by fleeting native guides who often abandoned the group without warning, the leader of the first American expedition to ever lay eyes on the canyon was not impressed (Fig 2). Hailing from the farms and hardwood forests of his native New Hampshire, Lt. Joseph Christmas Ives called the Grand Canyon a "profitless locality" and decreed that it would be "forever unvisited and undisturbed." He was wrong. Had he taken the time to ask his colleague, John Strong Newberry (a member of his own expedition, no less), Ives would have found a much different response to the "Big Cañon," as it was called at that time (Fig 3).

Newberry accompanied the Ives Expedition as their geologist, and was likely the first Anglo to see the Grand Canyon and appreciate it as something special and unique on our planet. About the Colorado Plateau he wrote, *"[These canyons] belong to a vast system of erosion, and are wholly due to the action of water. Probably nowhere in the world has the action of [water] produced results so surprising."*

He was spot on. Having the trained eye of a scientist, Newberry recognized that the Grand Canyon was not a giant earth fissure that only later became occupied by the Colorado River, but rather that the giant canyon was actually made by the river. Newberry and subsequent American geologists would use their experience here at the Grand Canyon and in the American West to further develop a branch of geology known as *fluvialism,* which investigates how the Earth's surface can be shaped by the action of rivers. Geologists in

Figure 4. Iceberg Canyon, Colorado River, Wheeler Expedition. *Photo by T. H. O'Sullivan, 1871. Courtesy of the Library of Congress.*

Europe had developed the concept of fluvialism early in the nineteenth century, but never imagined the magnitude of a river's cutting power before the deeply carved landscapes of the American Southwest were discovered, especially the Grand Canyon.

Figure 5. John Wesley Powell as he looked in the 1870s when he completed his second expedition down the Colorado River. *Photo from the U.S. Geological Survey.*

Thousands of geologists have followed in Newberry's footsteps, with George Wheeler (Fig 4), John Wesley Powell, G. K. Gilbert, Clarence Dutton, and Charles Walcott being only a notable few of his nineteenth century contemporaries (Fig 5). All of them were greatly impressed by the Grand Canyon's colorful rock layers, extreme topography, and enigmatic origin (Figs 6, 7). Just as the archaeological evidence has given us clues about the former presence of our prehistoric forebears, so too do the rocks here reveal evidence of their origin. It took centuries, even millennia, for humans to comprehend that the history of our planet is contained in rocks, but once this insight was achieved, the story of planet Earth began to be understood.

Exploring and discovering the Earth's geologic story was not about challenging religious beliefs. The earliest scientists in the days after the Reformation believed that science could show the precise manner in which the Creator had accomplished the task of creating natural phenomena such as the Grand Canyon. As more and more evidence accumulated, scientists, many of whom were outspoken Christians, became increasingly convinced that the history of the Earth was vast and complex.

Somewhat surprisingly, it was not until the beginning of the twentieth century that religious opposition began to be voiced against the antiquity of the Earth. In the 1920s, the Scopes Trial brought that controversy to the forefront of public attention. Thus, we find modern society confused and polarized on the topic.

Some who seek to discredit science nevertheless use modern devices bequeathed to them through scientific discovery and experimentation (such as medical advances), while they simultaneously discount other aspects of science that seem to conflict with their interpretation of the Bible.

To some people, the pronouncement that our planet was created "billions of years ago" is viewed as an attack on the Bible, but it need not be. It is a little-known fact that among modern professional geologists today who embrace the inspiration and authority of the Bible, the vast majority also understand the Earth to be billions of years old. These and other scientists observe and report their findings, much as Galileo, Newton, and others have done before them, seeking to find the most plausible explanations for what they observe. It is to be hoped that this controversy will, over many years, end much as the one with Galileo did.

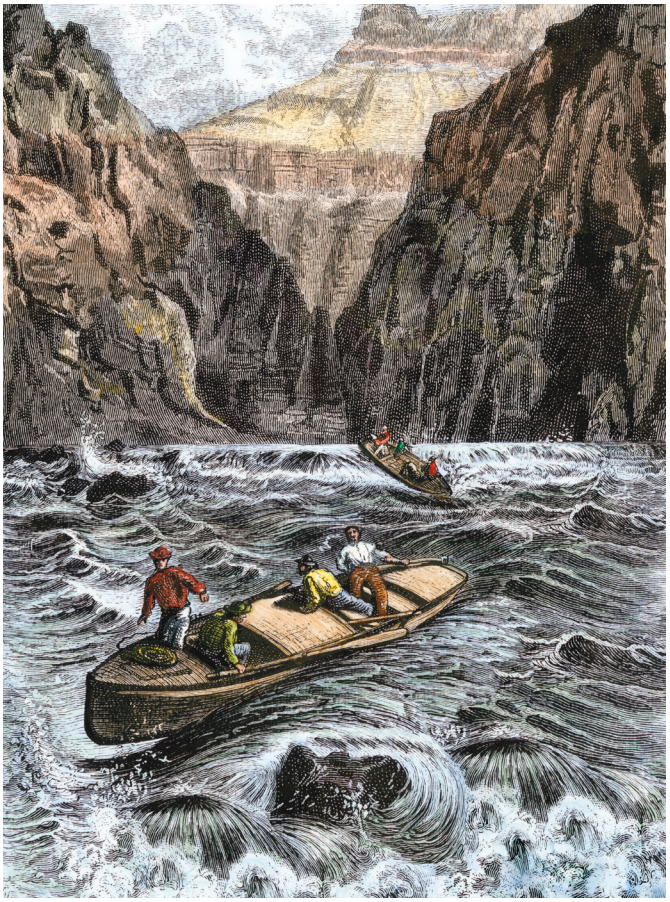

Figure 6. Powell's boat trip down the Colorado River of the Grand Canyon in the 1870s. Hand-colored woodcut. *North Wind Picture archives, EXPL2A-00144.*

In this book, you will find answers to questions you may have about the science of geology and how it works to arrive at certain conclusions. Geologists use many of the same scientific methods and techniques that have given us our televisions, microwave ovens, and cell phones. The petroleum that powers our automobiles has historically been discovered using methods arrived at wholly from an old earth viewpoint.

Flood geology, the idea that Noah's flood was responsible for laying down most of the sedimentary rock record, does not provide a credible scientific understanding of how oil and gas reservoirs have formed, with the trillions of barrels of oil, and enormous quantities of gas that fuel our modern society. Though few people realize it, to deny an old age for the Earth or the Grand Canyon, while embracing other aspects of science, is essentially a statement that science works only when we agree with the outcome. In this book, you will find explanations of how the Grand Canyon came to look the way it does, along with assessments of Young Earth/flood geology arguments to the contrary.

Many of the contributors to these chapters are Christians, while some are not. However, each of us is a student of the Earth who is troubled by what we believe to be a needless controversy that surrounds the story of the Grand Canyon. None of us presumes that acceptance of great age for the Grand Canyon will undermine religious faith. In fact, one early chapter offers insights into why an old earth view is actually *more* in line with biblical teaching.

In 150 years of scientific study, we have learned a great deal about how the Grand Canyon was formed. But like other branches of science, the investigative work continues and the story is not yet complete. This is because the Colorado River is an agent of erosion, and as it has become deeper and wider through millions of years, it has removed some of the evidence for its origin. But on the other hand, much *is* known about the formation of the canyon, and that is the story we present in this book.

It is truly remarkable that we humans, though tiny and short-lived, can yet peer deep into the past and reconstruct events never witnessed by human eyes. The Grand Canyon, by virtue of its grand exposures, has enabled us to not only be awed by its visual grandeur, but also to be enthralled by the incredible depth of time and richness of its history. Perhaps the greater lesson gleaned from the scientific study of the Grand Canyon is the humbling recognition that our own existence and inquiries, significant though they be, represent but a tiny sliver of the Earth's story.

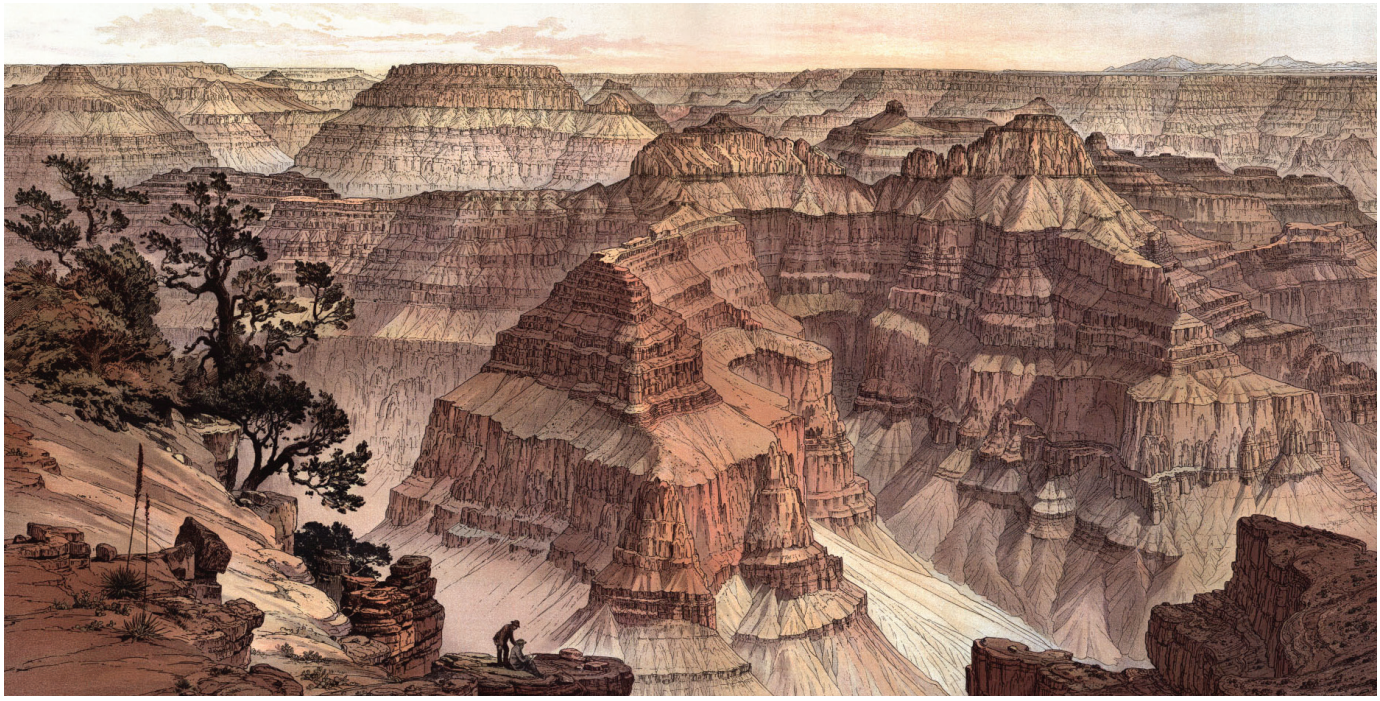

Figure 7. The grandeur of the Grand Canyon from Point Sublime; colored woodcut by William H. Holmes, 1882. *Courtesy of the Library of Congress.*

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PART 5 – A VERDICT ON FLOOD GEOLOGY

CHAPTER 7

USING THE PRESENT TO UNDERSTAND THE PAST

by **Stephen Moshier** and **Gregg Davidson**

UNVEILING THE PAST STARTS WITH an observation that processes at work today are producing rock and sediment formations with characteristics that are readily seen in ancient rocks. In the previous two chapters we saw that ancient sedimentary rocks, such as the Grand Canyon strata, can be compared to sediments accumulating on the land and in the sea today. The particles and sedimentary structures in ancient conglomerates, sandstones, shales, and limestones are not fundamentally different from sediments we find associated with modern rivers, lakes, bays, and the sea.

After 200 years of geologic study, it is clear that the basic geologic processes creating rocks today have been active over much of the history of planet Earth. These observations have led to an appreciation that the same physical and chemical laws in effect today were also in effect in the past, allowing us to use modern observations to identify ancient events and environments. This *uniformity* of natural laws gave rise to the term *uniformitarianism* and to the *Principle of Uniformitarianism,* which is one of the fundamental precepts of geology. Geologists have long recognized that natural processes can be slow (like coral reef growth or deep ocean sedimentation) or fast (like volcanic ash deposition), though some geologists of the nineteenth century tended to think that most of the Earth's rocks represented slow processes. Today, uniformitarian geology recognizes that there are many places and times where catastrophic events have contributed to shaping the Earth's varied layers, and that the physical conditions on Earth, such as the chemical makeup of the atmosphere and oceans, have not always been the same as they are today.

Misrepresenting Uniformitarianism

Flood geologists commonly demonize uniformitarianism by misrepresenting it as being synonymous with *materialism* or *evolutionism.* Yet when they seek to find scientific evidence in support of a young Earth, they actually apply uniformitarian principles! For example, some prominent flood geologists believe that the 1980 catastrophic eruption of Mount St. Helens provides clues to a rapid formation of the Grand Canyon. Specifically, the volcanic eruption delivered dozens of feet of sediment and ash in the valley below the mountain in the span of just hours. Later, an impressive gorge was carved in the very-soft ash sediment. The deposits contain layers and bedding, which flood geologists say look like rocks and cliff faces in the Grand Canyon.

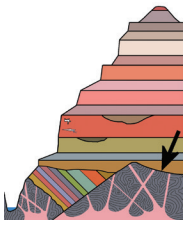
This comparison of modern deposits to ancient deposits is a fully uniformitarian exercise – the present (Mount St. Helens) is the key to the past (Grand Canyon). In this case, however, as in many other examples, flood geologists are not consistent in comparing apples with apples and oranges with oranges. The formation and behavior of volcanic ash layers cannot be directly compared with the formation and behavior of sandstone or limestone. The rocks in the Grand Canyon are made of entirely different materials from ash, and the immense size of the canyon's vertical cliffs (*much* larger than those found at Mount St. Helens) clearly testifies to the fact that the cliffs were already hardened to rock before they were cut by the Colorado River.

Flood geologists further depart from uniformitarian principles (and from Christian doctrines of God's consistency and providence) when they assume that natural laws describing physical and chemical processes must have been different during the creation week, before the fall in the Garden of Eden, or at various points during Noah's flood. Some Young Earth advocates write that the natural laws in the whole universe are a consequence of God's "curse" or punishment for the fall. These arguments fail to be supported by either science or Scripture. In science, all observations point to a consistency in the laws of nature, back to the first microseconds of the universe. The Bible likewise says nothing about the fundamental laws of nature being altered after man's sin.

Using Present-Day Landscapes to Recognize Ancient Landscapes

If the present is the key to the past, can we identify landscapes today that are comparable to Grand Canyon landscapes that existed in the past? We can indeed. To illustrate, we will visit five different sites along the canyon walls, each representing a different ancient landscape. We will apply what we described in the previous two chapters about sedimentary rocks – their composition and structures – to interpret the past.

Landscape 1: *Bare Naked Rock (Crystalline Basement Rock Exposed by Erosion)*



Our starting point, at the bottom of the canyon, is the Great Unconformity carved into the ancient Vishnu Schist (Fig 7-1). A modern analog (meaning a site today with very similar characteristics) is found in Canada, north of the Great Lakes, where large tracts of land are worn down to a nearly flat surface, exposing some of the oldest rocks on Earth (over 4 billion years old) (Fig 7-2). If today's ocean were to advance over this crystalline rock and begin to deposit sediment upon it, that would be comparable to the sediments of the Unkar Group being deposited over the older, eroded crystalline rock in the eastern part of the Grand Canyon.

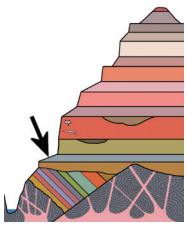
Figure 7-1. The horizontally layered Tapeats Sandstone over the Vishnu Schist along the Great Unconformity (hand pointing to the Great Unconformity). *Large photo by Wayne Ranney, inset photo by Gerry Stirewalt.*

Figure 7-2. Landscape #1. Ancient banded metamorphic rock eroded nearly flat along Georgian Bay, Lake Huron, Ontario. *Photo by Ted John Jacobs.*

Figure 7-3. Bright Angel Shale wall in the eastern Grand Canyon. *Photo by Tim Helble.*

Figure 7-4. Landscape #2. The reddish-brown muds of the Rio de la Plata, Argentina. *Photo by Wayne Ranney.*

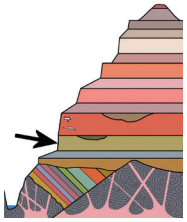
Landscape 2: *Muck and Mud (Clay Deposition in a Shallow Near-Shore Sea)*



Stopping point number two is the Bright Angel Shale, measuring about 270 feet thick in the center of the canyon (Fig 7-3). The clay-rich sediment of the Bright Angel Shale contains fossils of trilobites and abundant brachiopods, as well as fossil tracks and burrows.

Though these particular creatures are no longer with us, we nonetheless find modern environments that are accumulating the same-size particles (mud), where bottom-dwelling marine organisms make similar tracks and burrows. The muddy sea floor beyond the mouth of the Rio de la Plata in Argentina provides a modern example of the depositional setting for the Bright Angel Shale (Fig 7-4).

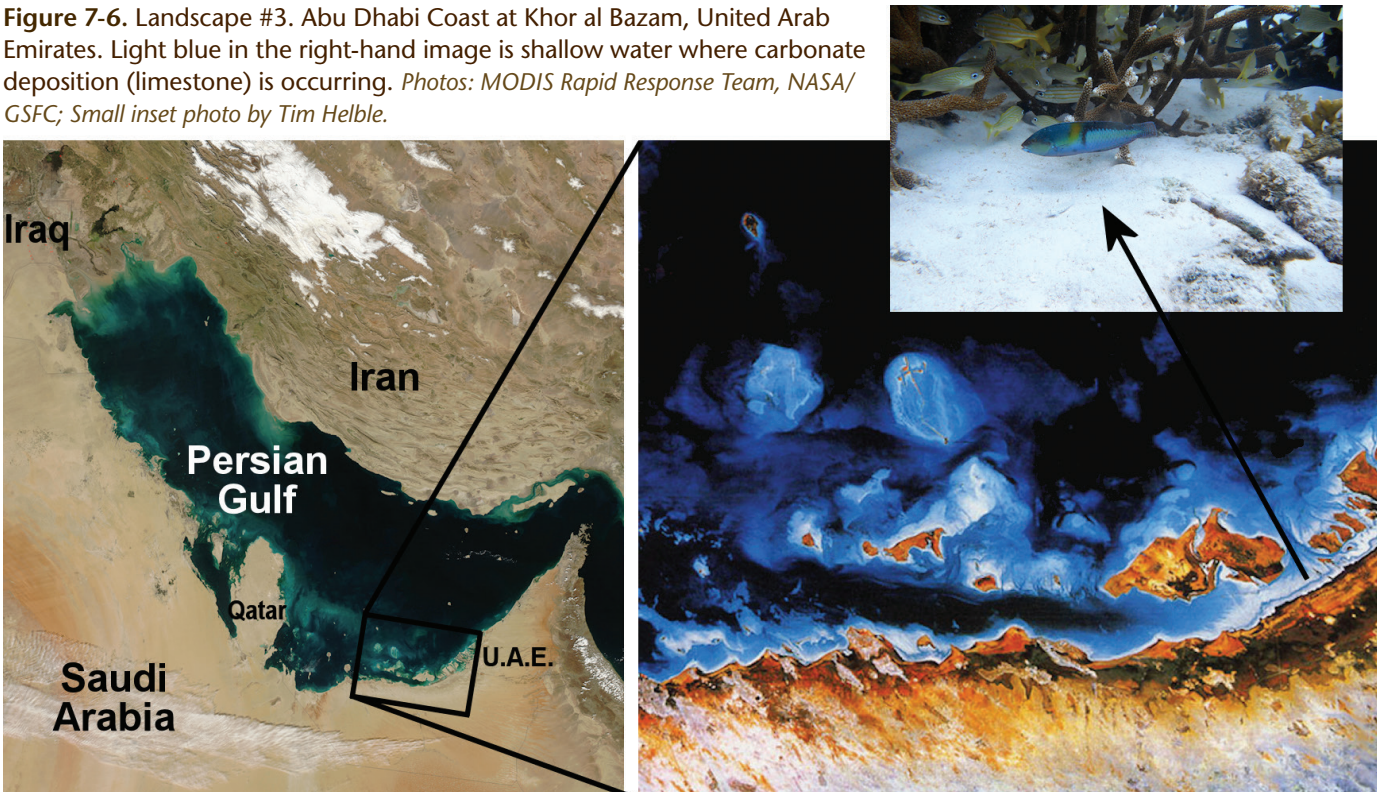
Landscape 3: *Vacation Destination (Warm Seas and Carbonate Deposition)*



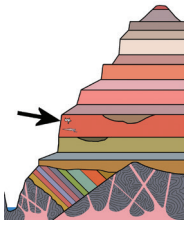
Moving upslope in the Grand Canyon to the Muav Limestone, we find carbonate sediments made from shell material, coral, and limey mud deposits (Fig 7-5). The transition from shale to carbonate here is consistent with rising sea levels (or subsiding land levels) and a change in the local environment to a more offshore setting that became isolated from the influx of clay. Modern analogs are found in places like the southern coast of the Arabian Gulf (Fig 7-6).

Figure 7-5. Muav Limestone wall, between the multi-hued brown layers of the Bright Angel Shale below and the Redwall Limestone above. *Photo by Tim Helble.*

Figure 7-6. Landscape #3. Abu Dhabi Coast at Khor al Bazam, United Arab Emirates. Light blue in the right-hand image is shallow water where carbonate deposition (limestone) is occurring. *Photos: MODIS Rapid Response Team, NASA/GSFC; Small inset photo by Tim Helble.*



Landscape 4: *Subterranean Labyrinth (Cave and Sinkhole Formation)*



Stop number four is the Redwall Limestone, one of the most prominent rock units within the Grand Canyon (Fig 7-7). It is the red unit that forms the sheer cliff face, from 500 to 800 feet thick, about halfway down from the canyon rim. If you look closely at the top of the Redwall cliff, you may see a horizontal layer with lots of holes in it. Some of these holes are entrances to caves that formed less than 10 million years ago. But much, much earlier than that, about 320 million years ago, the then-recently deposited Redwall Limestone was uplifted slightly above sea level. That uplift allowed freshwater to descend and circulate through the limestone, pockmarking it with thousands of sinkholes and caves over much of the area that is now northern Arizona. Caves commonly form in limestone when it is exposed to naturally acidic

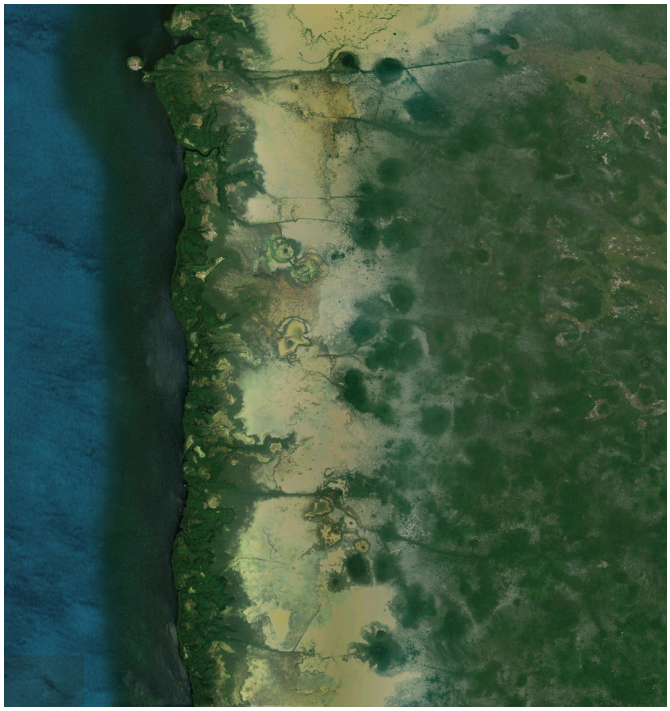


Figure 7-8. Landscape #4. Aerial photo of the Caribbean coast of Yucatan, showing cenotes, or sinkholes (the dark round circles), in the gray limestone. *Copyright 2013 TerraMetrics, Inc., www.terrametrics.com.*

Figure 7-7. Caves in the Redwall Limestone, eastern Grand Canyon. *Photo by Bronze Black.*

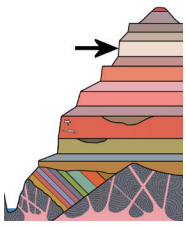
Figure 7-9. Cenote (sinkhole) at Chichén Itza, Yucatan, Mexico, located only a few hundred feet above sea level. *Photo by Emil Kehnel.*

Figure 7-10. A scuba diver near the bottom of a deep cenote in the Yucatan Peninsula, Mexico. *Photo by HP Hartmann.*

rainwater (conditions that exist above sea level). Caves near the surface often eventually collapse, resulting in sinkholes forming on the surface and caves filling with overlying material. (We will cover the topic of these old "paleo" caves in Chapter 10.)

We see this process occurring today in places like the Yucatan Peninsula of Mexico, where sea level has dropped and the limestone is exposed to rainwater that is slowly dissolving the rock to form caves (Figs 7-8, 7-9). Where cave roofs have collapsed, cenotes (sinkholes) have formed, and the caves are slowly filling with material washed in from the surface. In the Yucatan, these sinkholes are connected by an extensive underwater cave system that can be explored only by highly trained divers (Fig 7-10).

Landscape 5: *Hot and Dry (Desert Sands)*



The final stop is the Coconino Sandstone – the thick, distinctive, buff to light yellow layer just below the rim of the canyon (Fig 7-11). As we discussed in the previous two chapters, sand texture, cross bedding, and animal tracks in the Coconino are consistent with what we find in sand dunes formed through wind-driven processes, such as those in the Namib Desert in West Africa today (Figs 7-12, 7-13, 7-14). If sea level someday rose to submerge the sand of the Namib Desert, we would expect to find shale

Figure 7-11. The Coconino Sandstone, as it appears near the Bright Angel Trail. *Photo by Wayne Ranney.*

Figure 7-12. Wind-driven depositional processes at work. *Photo by Brennan Jordan.*

Figure 7-13. Cross beds in a modern sand dune. *Photo by Marli Miller.*

or limestone deposits beginning to form above the sand, just as we find the Toroweap (siltstone) and Kaibab (limestone) formations sitting on top of the Coconino Sandstone in the Grand Canyon.

Conclusion

In this chapter we visited sedimentary formations that represent five different ancient landscapes, each with analogous modern environments that are producing deposits with remarkably similar characteristics. These and other landscapes are reflected repeatedly in layers within the Grand Canyon and in the Grand Staircase to the north. As we have seen in previous chapters, no fantastic or never-before-observed mechanisms are required to account for any of these sedimentary layers.

To this point, we have noted that some rock types form quickly, like ash deposits, and others very slowly, like limestone, but we would prefer to be able to say more than just "fast" or "slow." How do geologists determine the time that was required to form an ancient rock layer and how long ago it formed? And are there debatable assumptions that have to be made to calculate ages? This brings us to the next two chapters, which address time and the ages of rocks.

Figure 7-14. Landscape #5. Shoreline along the Namib Desert, West Africa. *Photo by Amy Schoeman.*

Could the Grand Canyon's rock layers have formed in a single year of Noah's flood?

Why are there no dinosaur, bird, or mammal fossils in the canyon's layers?

How do we know that radiometric dating methods are reliable?

How can we tell what happened in the unobserved past?

How long did it take to carve out the canyon?

Is Young Earth Creationism really biblical?

Find answers to these questions and more in order to understand why the Grand Canyon is truly a monument to the great antiquity of the Earth.

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