

**Ch 18 GRAVITY CENTER OF GRAND CANYON GEOLOGY Mile 120.7**

You don't see it coming and hardly even see it when directly abreast of it, but Blacktail Canyon just ahead is surely a must-stop place for any raft trip in Grand Canyon. Some must stop to get shade on a hot afternoon. Others stop to play guitars or flutes in what is supposed to be a fabulous acoustic (which it isn't). Most stop to easily walk a short distance into one of the narrowest side canyons. Photographers stop for what can be magical lighting and unique walls. Geology trips focus on a spectacular outcrop. We are going to stop for most of those things plus an opportunity to consider the profound significance of the place with respect to the discovery of deep time and its effect on the modern psyche.

We park the boats downstream and walk back over a high, sand-covered pile of boulders that surged out of this slot canyon during past debris flows. We skip a visit to what I think might be low-walled Anasazi ruins on this rock pile closer to the river and ski/slog down sandy slopes into the bed of a creek barely trickling water where it sinks and disappears before our eyes into the sand and pebbles. This slot canyon is so narrow at its entrance that we should maybe call it a "slit canyon" (Fig 18.1).



*Fig. 18.1. A final look back to the outside world before fully entering the magic in Blacktail Canyon.*

Footgear choked with wet sand, we splash through brilliant sunshine and enter this shady refuge with blinded eyes.

For me, the opening in this cliff face is not an entrance but a portal. Passing in and letting our eyes quickly adapt to the diminished light, the great upward sweep of the Grand Canyon and its universe simply vanish. Instead, you focus up close on the gritty layers of the Tapeats Sandstone. They protrude out of the walls as smooth ledges stacked upward on both sides in great tiers. The walls of those higher up glow in a heavenly gold color impossible to describe or capture in an image (Fig 18.2).



*Fig. 18.2. Heavenly golden light high on the walls.*

The blue sky becomes a narrow, jagged band. There are profound places in Blacktail Canyon (Fig. 18.3).



*Fig. 18.3. Profundity in Blacktail Canyon—an experience not to describe in words.*

Although there is a short distance ahead to explore, I stop everyone and invite them to sit down or stretch out on one of the many inviting rock ledges (Fig 18.4).



*Fig. 18.4. Gathering up for a geology talk just inside the entrance.*

Here near the entrance is one of geology's grandest themes displayed with incomparable clarity. It is the most wonderful exposure of the Great Unconformity--the Tapeats Sandstone lying in knife-edge contact with the vertical bands of an even older metamorphosed granite/schist complex distinct from the Vishnu Schist and granite we passed through earlier. It is here a "gneiss" which refers to granite and schist that were themselves deformed during extremely deep burial. After forming at great depth, it was uplifted above the surface as a mountain range and then worn down by erosion to sea level. The Tapeats sea submerged it, and its eroded remnants sashed around on it to form this overlying layer. Many other events happened in the interval as documented elsewhere in the region. It is certain that all this uplift, erosion, and deposition took a large amount of time. The exposure is so clear and in such a magical setting that you can embrace and connect here with deep time like nowhere else (Fig. 18.5).

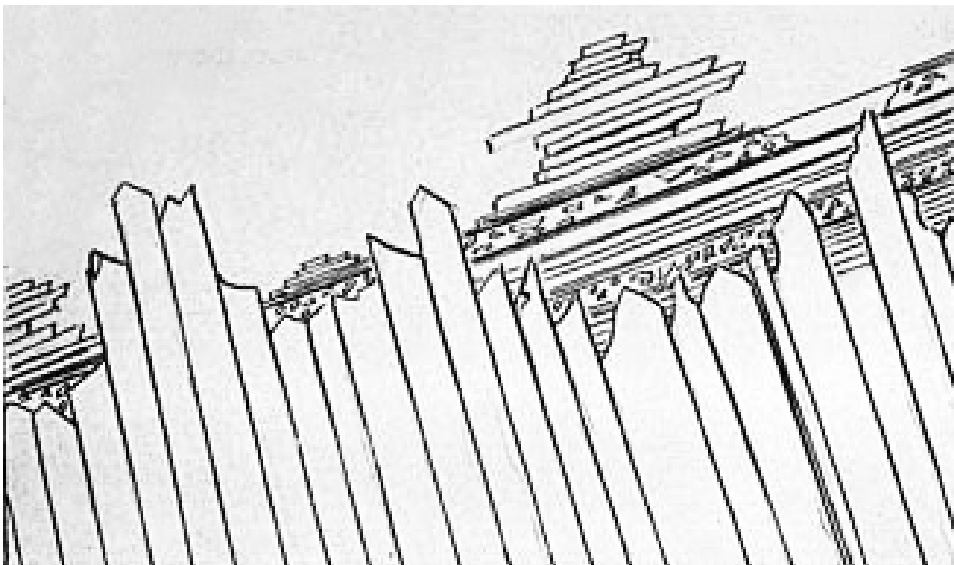


*Fig. 18.5. River Runner Darla Ekborn at the base of the Cambrian Tapeats Sandstone lying directly on Precambrian metamorphic rocks that formed about 1.7 billion years ago. This slot canyon is being eroded downward so rapidly that this is one of the freshest and most magnificent exposures of “The Great Unconformity” in the Grand Canyon.*

It is not often that a visit to a rock outcrop can revolutionize science and change how we think about ourselves. Imagine one that ripped away the very psychological foundation relied on during the development of Western Civilization! Okay, that isn't here in Blacktail Canyon; it is instead along the sea cliffs of Scotland. James Hutton, John Playfair, and James Hall passed it in a small boat on the way back to Hall's estate near Edinburgh while out exploring rocks along the coast in the spring of 1788. Hutton was a gentleman farmer who relentlessly pondered the implications of how sand and mud deposited in the streams and rivers of his estates were always piling up, getting breached, and moving downstream to a new site of deposition. He became prejudiced that the Earth was always being eroded and simultaneously reforming. He was particularly intrigued by “angular unconformities” where horizontal layers of sediment lie over older layers that are anything but horizontal. These had been described in scientific writings and interpreted in various bizarre ways, usually involving catastrophes. Hutton suspected instead that vast deposits in offshore areas had somehow very slowly tilted

up after deposition, become eroded back down to sea level, and then covered with younger sediment. The Earth's surface features were not static but changed and evolved very slowly with time. Big catastrophes were not necessary to explain unconformities if the time scale was greater than anyone ever imagined. He longed to see a spectacular example of an angular unconformity more convincing than the poorly exposed examples he had sought and found.

Historians can try to figure it out, but I suspect Hutton linked up with Playfair and Hall in the Oyster Club in Edinburgh at weekly meetings where the wealthy gentry seeking relief from the rigors of indolence discussed science and other lofty subjects. Playfair had left his job as a vicar to be a professor of natural philosophy at the University of Edinburgh. Hall was a local gentleman who conducted science experiments at his estates and once even tried unsuccessfully to start a tidal wave by setting off an explosion on the coastal ocean floor. It threw up a broad geyser of water--perhaps the first-ever depth charge. Both became intrigued with Hutton's ideas and joined him on a boat trip along the southeastern Scottish coast to look for a good angular unconformity. Toward the end of the day, one came into view at Siccar Point with waves crashing all around. What they saw stunned them according to a description Playfair published many years later. Here were strongly tilted sandstone beds with their upthrown sides chewed into by erosion and then partially buried by strata that were deposited horizontally—and then everything tilted up again to the present position. Modern erosion by the crashing waves was attacking it all again (Fig 18.6).



*Fig. 18.6. Sketch of unconformity at Siccar Point, Scotland, made by James Hall on the day of his visit there with James Hutton in 1788. A stack of sandstone layers (sketched here without an internal pattern) was deposited horizontally but was then tilted up almost into a vertical position. Erosion began wearing down the vertical layers to create the jagged surface in the sketch. Subsidence was renewed and new sediment began to form a stack of thin, horizontal layers over the top of the jagged erosion surface. Renewed uplift tilted the whole package up to the right into its modern position where erosion is now eating into everything again. All this was recognized by the visitors who realized an immense interval of time was required to produce this.*

All were sediments of sand that had been turned to sandstone almost certainly by deep burial. Hall had once tried to convert sand into sandstone by simulating increased burial temperatures using boiling salt water. It didn't work, so he surmised more time and pressure were needed to get the loose grains to cement together. So here they were. It was not a revelatory moment but rather unhinged joy at finding so splendid an example of what they had sought for so long. Every wave crash must have reinforced Hutton's general idea of the Earth constantly being worn down and then renewed. It all happened over intervals of time heretofore unimaginable. Playfair later described their excitement, "The mind seemed to grow giddy by looking so far back into the abyss of time." From that moment forward, Hutton's two colleagues became powerful advocates for the ideas he eventually published to great effect among geologists, academicians, and gentlemen scientists. However, 20 centuries of religious dogma in western civilization specified that the Earth was specially created for us humans by a supernatural deity in seven days as revealed in the Bible. And it wasn't that long ago.

Archbishop James Ussher, primate of all Ireland in 1650 even announced that his careful studies of long and tedious generational chronologies written in the Old Testament indicated that God had created Earth around 6 pm on October 4, 4004 BC, the first-ever example of what is known nowadays among astrophysicists as "precision cosmology." While all in those days knew that God had created the heavens and Earth specially for man, discovery of that actual date was considered a marvel of inspired scholarship. It is still the date Creationists use and want in our public-school science books as an alternative to Godless science. It has immense appeal because this cosmology gives our psyches an unquestioned and unquestioning foundation that allows us to be troubled only by more practical matters. We need not wonder with frustration where the world came from, why is it here, and what is its purpose. It is also used by those who want to exploit natural resources without environmental constraint because the same scripture says the end is near (and thus there is no need to preserve our world for future generations). The consequences of this way of thinking are significant and scary to those who courageously view the world in terms of rational thought. Courageously? Yes. The same believers in the supernatural often ridicule and lambast rational thinkers as ungodly agents of dark forces threatening their faith.

A short excerpt from the magnificent oratorio "The Seasons" written in 1798 by Franz Joseph Haydn charitably says more than reason can comprehend regarding the schisms plaguing modern thought and politics. Haydn was an Austrian composer much admired and celebrated in his time. His sublime musical settings of Biblical cosmology in his oratorios "The Creation" and "The Seasons" continue to move people deeply to this day (including me). He was a true believer who clearly went into spiritual ecstasies derived from the religious teachings of his day. There is a remarkable part of The Seasons in which a sunrise is depicted. It starts in dark morning twilight barely audible with quiet strings and soprano. Slowly increasing in volume and orchestral forces as the sky brightens, a baritone joins in. Then more instruments and a tenor. All swell upward as the sun begins to rise. The full chorus and orchestra carry the crescendo to a tremendous, ear-shattering climax as it clears the horizon in

a blaze of glorious light. With full brass and thundering drums, the climactic chord stands like a great monument in the blinding light of the fully risen sun. Then, an ecstatic hymn of thanksgiving erupts and goes on and on until all is spiritual delirium. A great performance of this can turn you into a heap of goosebumps. To Haydn, sunrise was not the Earth rotating around until the sun reappeared above the horizon. It was instead a pageant directed by God! Indeed, many at the time considered it to signify the daily ascent of the Godhead itself.

The Seasons in its entirety is all about how people, especially peasants, should happily get on with their daily work. If they are virtuous, God will send the rains and crops will grow. Winter will end and God will renew all. Inner life is as simple as these daily tasks. The world was made especially for you, and you need only have faith, work hard, and be virtuous to reap heavenly rewards. That's all there is to it; praise the Lord. This was the de facto Western mindset still going strong well into The Enlightenment when the western mind began to put faith in reason as much as it did in religion.

Of course, the discoveries and theories of Galileo, Copernicus, and Kepler had been earlier, so rational thinkers already realized that sunrise could be interpreted in a more scientific way. But now--along came Hutton with his notion that 6000 years is clearly an altogether inadequate time to explain the story clearly laid out at Siccar Point. He famously concluded in 1788 that regarding geologic phenomena, "we find no vestige of a beginning--no prospect of an end." About the same time, here came the first trigonometric measurements of distances to the closest stars. They were incomprehensibly large to human senses and remain so today. Then Darwin entered with his theory of evolution. This was initially viewed with favorable puzzlement but changed into outright hostility when he suggested it was obvious that people are animals and thus surely evolved out of the great fossil progression documented in the rock record. The evolutionary rock record is not a philosophical concept or a subjective human construct. It is foundational knowledge that we can hang our hats on. Suppressing or distorting this record for religious or political purposes is not nor cannot come to good.

Today, objective science moves forward at an ever-increasing pace. The immensity of the universe in which the Earth is but a miniscule and insignificant speck is considered as certain as the Earth is round. The modern scientific view of nature and its history stands in irreconcilable conflict with the previous grip on our outlook that we are the center of creation and that it was all done specially for us. Whether we want to believe it or not, we are physically insignificant in space and time and part of a story never dreamt of in any religious teachings. Yikes! All of science says that the comfortable, reassuring, and simple notion that we are the center and purpose of a universe created just 6,000 years ago simply isn't true. The very foundation of the collective Western psyche assumed for thousands of years has been ripped out from under us. Now we wonder and fret over what it is all about and what it might mean. How complicated and spiritually dangerous it is now to operate in a world so different from what Haydn felt. His musical description so filled with spiritual ecstasy could not be written today. Beautiful and inspiring music, yes. But no one today thinks a deity is regularly ordering up the daily sunrise.



Mess with the human psyche in this way and prepare for personal angst, an onslaught from the faithful, and convoluted rationalizations to “merge religion with science.” I worry most about lingering, subconscious religious prejudices that may even alter our scientific paradigms. People still brought up and subjected to heavy doses of Judeo-Christian teachings but wanting to face reality with reason, evidence, and logical ethics have especially difficult issues to confront. I really irritate my astronomy colleagues with their staunch, unquestioning “belief” in the Big Bang theory when I kid them that they have found a way to assuage their subconscious guilt and come home to their childhood-taught version of “Let there be light.” When I ask how else they can post with such speed to a belief that the entire universe and the “laws of physics” instantly expanded out of a pinhead of nothing to become a universe of energy and matter both of which are greater than 90% unobservable but which they adamantly insist are there-- all “precisely” at 13.799 billion years ago. Nay, not so much. Not a pinhead; an infinitesimally small dimensionless point known as a “singularity” in the undefinable nothingness. When I suggest they may want to explore alternative explanations that don’t involve such apparent absurdity, they usually scoff that I don’t understand the laws of physics or the observational data. I actually do and recognize that the laws of physics themselves are a description invented to quantify nature for practical purposes. These “laws” are not an explanation of causation. They are ultimately numerical expressions constructed to use the mathematics we invented first to count and then to measure and then to model natural processes. Amidst so many variables and assumptions required to use them, they cannot reveal or document natural history and cannot predict the course of future history. Which laws of physics predicted trilobites? So how can any two modern people think and feel alike--how to reconcile all these contrasting faith-based and science-based claims on their souls? What a psychological mess humanity has become—much of it almost certainly from the scientific campaign triggered by that afternoon amidst waves crashing at Siccar Point.

So here we are in Blacktail Canyon pondering one of the biggest issues in science and how we view the world. The angular unconformity here represents a missing time interval that puts Siccar Point to shame. The ages of the two units on the Scottish coast are now argued to be about 345 million years for the horizontal younger sandstone and 425 million years for the older strongly tilted one. The 80-million-year time difference is inconceivably longer than 6,000 years. The angular unconformity here in Blacktail Canyon is even more pronounced. The banding in the Precambrian crystalline complex is over 1.7 billion years old, and the horizontal Tapeats Sandstone slicing across it was deposited no more recently than 500 million years ago. The exact ages are continually refined, but it is a gap in time on the order of 1,200 million years--15 times greater than Hutton’s prime example that so influenced the scientific and psychic worlds. Put your thumb on the gneiss and your fingers on the sandstone, and you have deep time in your hand. Unless our science is catastrophically wrong, it is also during this missing interval that the chemistry of the atmosphere and oceans changed, and animal life exploded to fill niches never before occupied. Stars in the sky came and went and constantly arranged themselves into patterns never seen before or since. Continents drifted around the

globe to form a supercontinent that broke into pieces—some of which were transported to the other side of the world. Land surfaces sparsely populated with tiny photosynthesizing ground huggers expanded to make most continents green. Vast sedimentary basins formed, sunk down into the Earth, lifted up again, eroded, sank, and rose again in unknown ways at unknown times. Meanwhile, heat escaping from deeper down relentlessly churned the innards at a snail's pace to generate uncountable volcanic eruptions. Deep time signifies more than time, and here it is between two fingers of your hand. The work of thousands of passionate scientists comes forth between those fingers to put you on a Mt Everest of human comprehension. I always stand here dumbfounded and numb because I seem to viscerally feel all this. After expounding to the group sitting on several tiers of sandstone benches and then freeing them to explore on their own, I am gratified to see most go up to the canyon wall and stretch fingers across the unconformity in awe. Yay. I do not tell them that they can do the same between the gneiss and the sand currently washed in along the floor against the wall. That's a gap in time of over 1700 million years with even more profound events in Earth and life history missing in the gap. It is all Hutton's Earth constantly being torn down and renewed over inconceivable intervals of time.

As people drift off to explore the canyon, I am left again with treasured moments alone. I fixate on the horizontal layer of coarse gritty Tapeats sandstone. The sizes of the grains range from very fine to chips of white angular quartz to chunks about half the size of a human fist. The grains and chunks got pounded into smaller sizes the longer they were exposed to the energetic swashing and crashing of wave after wave if my interpretation is correct. Those larger pieces had not moved far in the currents and waves that smashed against the gneiss when it was first flooded by the encroaching ocean. Below the contact, white vertical quartz veins in the gneiss jut upward and are simply cut off by the lowest layer of Tapeats sandstone. The quartz veins were obviously much harder than their adjacent gneiss layers, for several here stick up many inches into the overlying sandstone. Angular chunks lie to the right of one such vein. A vein is a cross section through a sheet-like feature. This was at the time probably a little erosional jetty sticking up in a shoreline surf zone of the Cambrian Sea. As waves or currents smashed into it from the left, pieces ripped off and got buried in the swashing sands to the right. One chunk...another crash...another chunk thrown down. And so on. I count three big pieces and many smaller forming a kind of train on the right side. Incredible. I can hear and see it all in form as palpable as the background roar of the rapids we are now so accustomed to. Blacktail Canyon has become a time machine, and I am tumbling around in it. How amazing it would have been to witness this coastline. As Playfair noted, "...we became sensible how much further reason may sometimes go than imagination may venture to follow."

My treasured time in isolation ends as the fabled acoustic fills with the cacophony of approaching voices. People are already returning from having gone as far in as possible. Blacktail Canyon ends for pedestrian traffic at a small waterfall wall less than 100 yards up from the mouth, so our exploration here is necessarily brief. Water is usually weeping down

that trip-ending wall amidst green slime and into a small plunge pool that overflows and trickles along until it disappears into the gravel of the floor near the mouth. I rush up the canyon past my approaching friends to take my annual look. The gneiss is eroded into pillar-like push outs along the walls of the narrowing slot. The ambience suggests I am wandering in catacombs of time as I approach the little pool. My homage doesn't last long because another group has landed and will probably start exploring the acoustics with a guitar, flute, singing, howling, or their own geology lecture. Memories return of a previous trip where my daughter and I had our picture taken in front of this little stream plunging off the Tapeats and falling over a billion years down into the Precambrian (Fig 18.7). It only takes falling water a second to go back a billion years. I salute the time-traveling rivulets and weave back through the oncoming crowd toward the exit. This holy place is theirs now, and my own screwed-up psyche quickly tumbles back out into the blinding sunlight of modern time.



*Fig. 18.7. Water falling over 1 billion years behind father-daughter photograph. (Image courtesy Michael Nolan)*