Chapter 7 WHERE TIME BECOMES SPACE Mile 20

We arrive at camp at the mouth of North Canyon in the shade of huge walls capped by the Kaibab Limestone shining fiercely in the late afternoon sun. The eastern wall across from this campsite during the upcoming sunset pageant is of such majesty that photographers, poets, and writers first realize here that human feelings experienced on a raft trip through the Grand Canyon can never be adequately conveyed or expressed. In this first day of travel, we are already deep into this other world that now seems like an immense roofless cathedral. After setting up camp, most of us start a hike up this magical side canyon through the same Supai ice age strata we saw at Ryder Canyon. Where side canyons are large and well developed, they can have a curved floor full of sand and cobbles easy to walk on. Steeper ones can't hold this debris and it washes down to leave the eroded bedrock surface exposed to the elements. North Canyon is a steep climb up a rock staircase defined by protruding layers of hard sandstone better able than shale to stand their ground against the erosional cleaver descending from above. Rockfalls off its steep walls during heavy rains crashed and surged down this canyon innumerable times as happens in all these side canyons. They scoured the floor to bare rock, ripped protrusions off the walls, and shot the thick debris out across the river all the way to its far side. North Canyon rapid is another work in progress with the river trying to flush out the rubble from these past floods now in its way.

The debris flows that intermittently come down North Canyon are greatly outnumbered by simple floods initiated by heavy rains. These leave the layered rocks scoured into illustrious staircases in places easy to ascend (Fig 1).

Fig 7.1 Erosion of alternating sands and shales can produce a natural staircase.

The more agile of our hikers often help others over the larger steps by offering handholds from above. A river handhold involves palm to inner wrist grips from both parties. Along the way, curious stringy white zones in some of the sandstones attract attention. Many are also present as vertical stringers in the mudstones exposed on the walls and are easily interpreted as calcite encrustations that formed around roots of plants growing in arid coastal flats. A lot of the horizontal ones are probably the same. Many may result from organisms that burrowed in the muds to feed on organic scraps brought in by the tides. This area of 280 million year old coastal sand and mud deposits was clearly seething with life even though we do not see any actual fossils. Good fossils are not common in the Supai, but ancient life has left plenty of other evidence that it was here in abundance during the time these sands and shales were being deposited.

At several places, even the most casual observers are struck by layers of knobby, rounded, white calcite globules all tightly packed and cemented together. They look just like typical conglomerates and gravels, but calcite is usually not tough enough to form rounded cobbles like this. It is one of the softer rocks and can slowly dissolve as it gets pulverized in river deposits. So, these weird layers leave most geologists puzzled. Fortunately, an extensive bed of this same conglomerate occurs near the top of this same Supai Formation where it crops out along the Mogollon Rim 65 miles to the southeast in central Arizona. I started and ran a 5-week summer field school for 15 years in that area where this peculiar layer is prominent. My curious and indefatigable grad student Ray Kenney got intrigued with this puzzle while he was my teaching assistant there and played Sherlock Holmes. He eventually published a paper with geochemical data arguing that these were nodular calcite encrustations called rhizoliths that form around roots of plants growing in semi-arid regions. They were not eroded into rounded cobbles; they formed with these shapes. As sea level retreated and the muds were washed away, these more robust nodules were left behind and washed around by braided streams and tidal channels to form these conglomerate layers that are so puzzling. More evidence of abundant life here in the past.

Our explorers come across a number of striking “potholes” on bedding plane surfaces (Fig. 7.2).

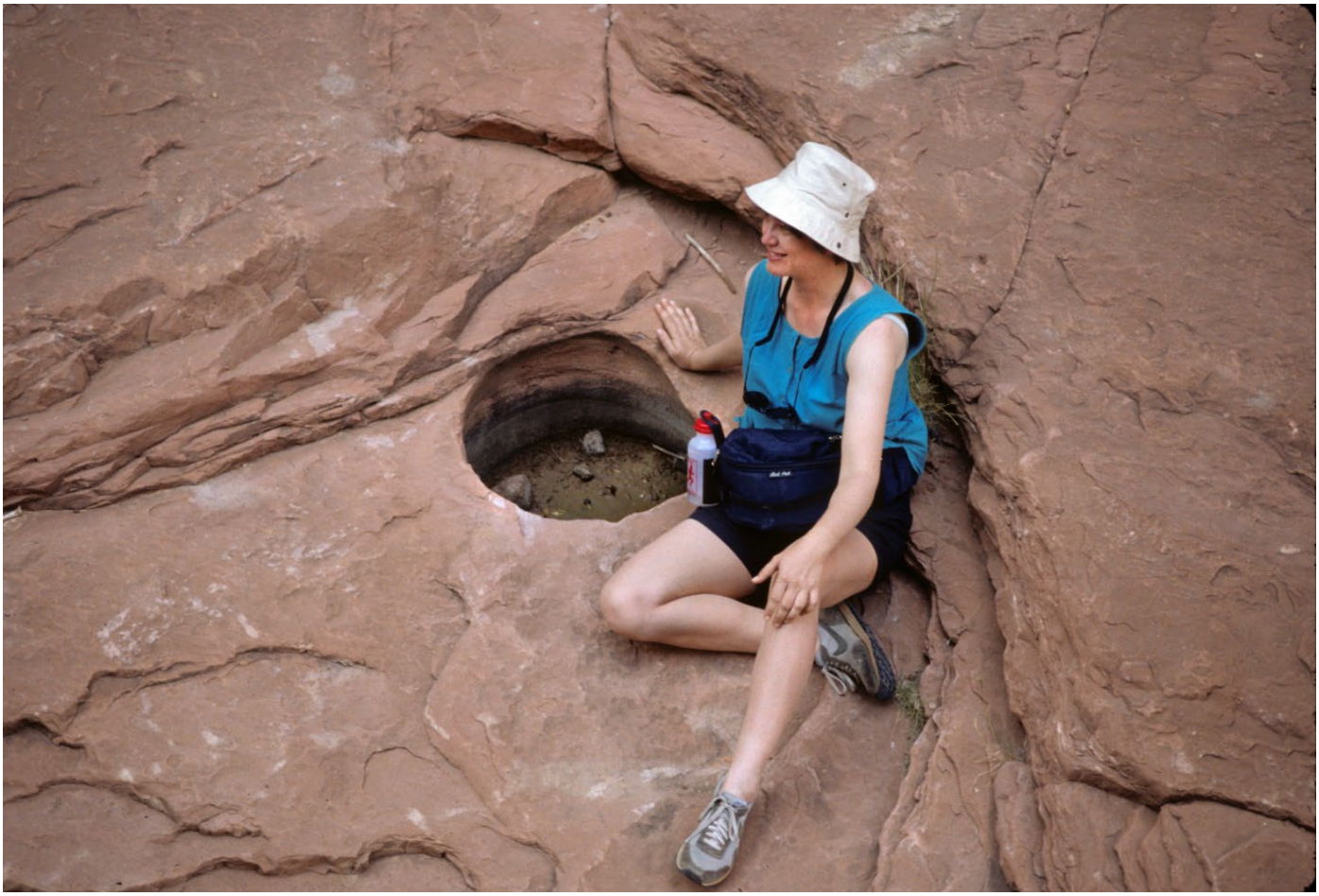

Fig. 7.2. Potholes on floor of North Canyon. Small stones spinning around can erode out cylindrical depressions. Are these from modern flows after storms, or is this an ancient feature dating back to the original deposition of the sand and possibly only being excvbated and enhanced by the modern flows?

These apparently form when fast, turbulent currents flowing over a smooth surface develop little tornado-like vortices that stay in place and swirl around to create a depression. Small cobbles that fall in are swirled around to grind out an almost cylindrical hole. How deep can they excavate? When did they form? Can potholes filled with sand following their formation be preserved in ancient sedimentary rocks? These are currently not some of science's greatest questions, but there are endless, ignored details in geology that sometimes become important later on. Those questions are really not answered even where the river has cut down through, or undercut beds so that you can look upward and see the sky through them (Figs. 7.3, 7.4).

Fig 7.3. Side view of former potholes in sandstone layers of the Supai Formation on river right somewhere around mile 14. A dozen penetrated at least down the entire thickness of this protruding sandstone layer. Were they formed by the river as it cut down through this bed or did the river preferentially erode out ancient sand that was once in them?

Fig 7.4. Looking straight up through a pothole in Supai Sandstone layer at lunch stop somewhere around mile 14. Did the large rock inside just fall in or was it spinning to help create the pothole? Endless puzzles abound in the Grand Canyon. Some are important.

Potholes on the floor of North Canyon are a good place to trip, but “dry waterfalls” are a bigger concern. This is the term hikers in narrow canyons use to describe a rock wall across the route that must be surmounted to continue upstream or a sudden cliff that stops easy descent if hiking downstream. Of course, a dry waterfall quickly becomes an actual waterfall following even modest rains. All waterfalls everywhere are ephemeral features. Water cascading over the step wears away the edge while turbulence in the plunge pool gnaws away at the bottom of the wall it just fell over. Once undermined, the whole rock face collapses into the pool and quickly or eventually washes downstream. So, waterfalls slowly migrate upstream. Come back in a thousand years and even the famous Niagara Falls will be miles upstream from where it is now! In the more arid canyons out here, the step moves more slowly, but ephemeral it is when viewed with long eyes. Every sandstone step in North Canyon is a manifestation of this waterfall process. Under each sandstone step surface is a layer of shale that will wash out faster and eventually allow the overhanging sandstone step to fall away during a flood. The height of the steps depends on the thickness of the individual layers. Some steps are too high to step or climb over, so the only hope there is to scramble up possible mounds of rubble piled up against the adjacent walls. Where even that rubble has been swept away, there is no easy way to surmount the wall to continue. No two side canyons are alike, but all are picturesque. This one with its amazing fracture swirls can inspire awe even in those not predisposed to gasp at scenic wonders (Fig 7.5).

Fig 7.5 North Canyon

Our scramble up North Canyon comes to an end at a pool of waist-deep water. Here we stop because it is rather slimy water today and there is no enthusiasm for slopping up the smooth chute on the far wall. Besides, we are gathering here immediately after passing through a set of fractures straight out of a science fiction movie. A bright green cottonwood tree is springing back to life amid these brown concentric swirls that sweep down and across the floor from wall to wall. People linger to gawk, wonder, and then slowly step up to the little amphitheater collecting us human intruders now blocked in this special place. The view from the lip of the pool both upstream and back across this psychedelic array of fractured rock overloads the senses. Only seven hours earlier, we were at the boat launch still immersed in the cares of the civilized world. Passage into this other world now seems complete. The inner selves of the people before me seem to be resetting toward blank slates regarding the scenes before them. I am glad that no one has apparently seen a certain IMAX movie about the Grand Canyon which opens with a terrified Native American boy fleeing ahead of nomadic invaders and sliding down the chute into this very pool. Instead, everyone wants to know about these strange fractures.

I relay the conventional story geologists tell here about how stream incision dug this slot into the ground so fast that the pressure on the walls could not relieve itself before it blew parts of the wall off. This happens in deep mines where miners are injured or killed by “rock bursts” that suddenly spall off thin slabs without warning right into the newly formed opening. A swirling fracture texture is left on the walls in those cases that resembles what we are seeing here. Everyone seems satisfied and maybe I should leave it at that. But…the mine examples are on a much smaller scale, and we passed numerous other examples in this very level when we passed through it on the river earlier today. As we continued, they were visible throughout the layer which became progressively higher as we floated downstream. Here, we have just walked back up to the level of the layers in which they are developed. So, I must confess to my crowd that they probably should consider the standard geologist’s explanation as only a possibility. Now the disturbing truth of the scientific endeavor begins to publicly unwrap. Scientists expound, textbooks are written, sensational news releases about new discoveries are publicized…. and much of it is overstated, just a guess, and often wrong. Here the conventional wisdom seems easily rebutted because we just do not see this remarkable pattern in other side canyons that surely formed equally as fast as this one. So, what did happen to make this crazy pattern? People want an answer. Well…I do not know and neither does anyone else. Bingo, we have seen some amazing scenery today, I’ve expounded some basic geology that likely accounts for the nature of the colossal rock layers, and now I get my first crack at screwing up the minds of people who aren’t skeptical enough about scientific results. No, I do not want them to distrust science. I want them to get a realistic grip on it. They need that, and so does our society. And so do I, which is why I’m on this pilgrimage they know nothing about.

Before we head back to camp, I do offer an alternative explanation involving the homogeneity of this sandstone, the fact that it has very large internal cross beds, and how

such a rock layer might respond to the expansion forces that occur when areas of the continent are uplifted tens of thousands of feet. It is just a combination of the normal fracturing during uplift combined with an exceptionally homogeneous sand layer that was deposited in large crossbeds. The normally vertical fractures here intercepted the big crossbeds and then cracked down through them in this swirling fashion. But we really don't know, so let's go back and have dinner.

I hang around and am left alone as people filter away. A small bird flits into the lush green leaves of the cottonwood tree that became reestablished after the last debris flow. It lets out a startling sound and departs. That beautiful little tree is senseless life trying to thrive but certain to perish with the next debris flow that comes after the next big rainstorm. I get lost in thoughts of how transitory everything is. The tree has no long-range future, but then neither do any of us. The moment counts, and this is a beautiful place to have moments. Alone here, I understand why my friend Bill Lieske who went on many of my trips used to charge up here ahead of the group to have some minutes of silence in this special place. And then there is Howard Bond the noted astronomer on many of my previous trips who related a profound experience he had here after everyone left. A great almost deafening cacophony erupted from dozens of tiny frogs that had been hunkering down along the pond margins while the group was here. He became entranced. It was not the Wagner operas he loves; it was music of a different kind made magical in North Canyon. No frog opera this evening and the water on the pond is now completely still. The fracture pattern swirls down and joins symmetrically with its reflection swirling in the other direction. The fading blue sky reflects in the water film trickling down the far side and both reflect again off the smooth surface of the still water. In this light and time, I stand riveted in one of the most phantasmagorical places in Grand Canyon (Fig 7.6).

Fig 7.6 The pool in North Canyon in late afternoon.

Time seems here to have become space. My soul seems to vibrate in winds from other worlds. The bird flits again reminding me that this condition is one we animals may have suppressed during our evolution to remain environmentally aware of ever-present dangers. It is getting late and it is time to get back to camp. I have been here many times before when North Canyon was just another side canyon. No, this place must be experienced in the late afternoon but not too late, else there is a scary hike back in the dark. I return to camp and find everyone in chairs arranged in a giant circle while the crew finishes cooking dinner.

Sitting back in a comfortable chair near a rapid at the bottom of Grand Canyon and watching the drifting shadows and changing sunset colors on the far wall is one of life's greatest experiences. Here at North Canyon, the major player is the almost vertical wall of Coconino/Toroweap/Kaibab formations finely sliced by thousands of vertical fractures, many of which terminate at individual horizontal layers. Like many other spots, the walls here resemble blocks carefully stacked vertically and laterally like those of a great cathedral. Were it not for the expansion cracks developed during the uplift, there is no telling what kind of chaotic or random pattern would be here instead. Directly across from us is a cross section through layers of the Supai sandstones and interbedded, recessed, deep red shales also sliced

by the almost hairline vertical cracks. Thousands of human eyes have watched the same display with similar feelings no doubt. However, knowing and understanding that the alternating sandstones and shales in this formation likely resulted from the rise and fall of sea level during melting and refreezing of enormous ice caps on the south pole imparts an additional awe factor. The wall decorated in shadows and glimmers becomes a monument and a record of a great event in Earth history over half a world away at the time--an ice age with its global consequences.

The thinner, red shale beds between the sandstone layers are identical to the thick accumulation that make the Hermit Shale Formation we passed through earlier. Indeed, it is often said that the overlying Hermit is just the Supai without the sandstone beds. What could have caused the end of sand deposition in the Supai to form just the Hermit shale? The Hermit contains fossil evidence elsewhere of being floodplain or inland coastal deposits. Did the ice age end and leave this area to subside with sea level relatively stable for several million years? Or did the source of the Supai sands stop shedding beach sands because of change to a drier climate with less runoff following the Pennsylvanian ice age? Or, did the distant mountains get worn down to where rivers draining away from them got starved of sand? It is the age-old question geologists face when dealing with “detrital” sedimentary rocks, those composed of grains transported from elsewhere to the site of deposition. Just where did the sand come from, how did it get here, and why?

The famous Penn State geologist Paul Krynine once said, “Show me a thin section of a sandstone, and I will tell you the history of a mountain range.” By that he meant he could identify the type of distant igneous, metamorphic, or sedimentary rock that was being weathered to produce the detrital particles. A rock is sawn into a tiny rectangular piece about like a really small matchbox. One side is polished and then glued onto a glass slide. The other side is then ground down to a thickness less than a sheet of paper and polished again. Light can then pass through almost any rock so prepared. Under a special “polarizing” microscope it is possible to see a universe of details in these “thin sections,” even domains where all the atoms are aligned systematically in one direction in a single grain. Quartz from metamorphic rocks is different from igneous or sedimentary rock quartz when seen in thin section. Spotting quartz grains with abraded overgrowths of a second generation of quartz easily visible in this kind of microscope means that this was once a sandstone that was buried, cemented with new quartz, uplifted to form a mountain, weathered, eroded, and deposited again. Quartz grains with multiple overgrowths of abraded quartz are found that indicate two or more cycles of burial, uplift, and erosion. Krynine could do all this. Today, it is becoming a lost art because microscope skills like this are expensive and time consuming to teach. I did it early in my teaching career, but institutional obstacles prevailed. There are today fewer and fewer microscope experts left in our field. This has led to a lot of published blunders. Fortunately, it is now possible to use high tech instruments to age date individual grains of zircon grains in sandstones using a method best discussed in a different context at another place. This mineral is hard and resistant to abrasion and therefore common when granites which normally have

zircons contributed to the sand in the source area. So, plot the ages of about 30 random zircon grains from a sandstone on an age line and you get a sort of bar code representing ages of rocks in the source area of the ancient sandstone you are studying. This has been done for many of the Supai sandstone layers and the bar code surprisingly matches closely that of sands eroding off the Appalachian Mountains today. It seems impossible at first to think sand could have come across the continent in rivers to distant Arizona. But look at how mountains in the Dakotas and even Colorado supply sand to the great Mississippi river that moves it all the way to the Gulf of Mexico. Some similar kind of monster drainage network must have extended in Pennsylvanian time all the way over to here if the data are being interpreted correctly. How apt that the Supai is "Pennsylvanian" in age.

This combination of science and magnificent surroundings invokes wonderment and exultation as I sit back in this ringside seat. It has been only three days and I have already asked myself several times "how many eyes in human history have beheld this"—first the realization of star wars at work as viewed from Shoshone Point, then the Permian land surface during the greatest mass extinction in Earth history, crystal containers possibly holding clues to what caused the extinction, life screaming out its influence on what we see at Desert View, and now all this to name a few. The shadows of approaching night move up the higher walls like a curtain rising upward to cover the stage. The Mt Everest of this pilgrimage is apparently going to have many summits.

The spell is broken when a surprisingly large beaver begins working along the greenery at the bank right in front of us. Although deep in twilight, it is the best view I have ever had of one of these bizarre creatures. The aerodynamic water-slicked head is gray with brown spots and attracts a lot of attention. Yikes, a rodent has photobombed my profound ruminations. Ah well…I am never so tired as at the end of this first day on the river, so I head off to find an isolated spot to set up a cot.

The first night on the river is always a relief. We are underway and have already encountered scenic and geologic splendors beyond expectation. People who have never camped before are relieved after setting up their tents and experiencing a great dinner in an incomparable setting. The chatter dies down remarkably fast after dark. All of us tired river runners drift away to our separate little campsites and commit ourselves to sleep.

The soft roar of the rushing water in North Canyon Rapid is unique and distinctive. It resonates off the hard rock walls to scare novice boatmen, but its continuous soothing sound gives rest to us weary travelers. The anxious nights before a raft trip are restless, so this river cradlesong lulls us toward a blessed sleep. The rapid is not only clearing out the riverbed; its sound is sweeping away the anxieties, cares, and concerns of our lives in the Rim World above. Now we are free to enter what poet Roger de La Mare called "the enchanted realm of dream that burgeons out of night."