Ch 11 **THE DARK SIDE OF THE CAMBRIAN** Mile 41-53

About one third of the sedimentary layers we floated through in the previous two days were crushed and munched shell fragments of innumerable past organisms reconstituted into layers of hard limestone and dolostone. We saw fossils that survived the conversion in only a few places, and this is typical. Had we crawled around where slabs have fallen or weathered out as ledges, we would have found occasional layers where fossil preservation has been exceptional. Paleontologists seek these out all over the world and spend days digging, cracking, and brushing with patience and enthusiasm. Together, they have assembled one of the most remarkable, ongoing discoveries in the history of science. The kinds of fossils found in great stacks of sedimentary layers like those we have gone through display a recognizable order going bottom to top--from older to younger. A given type of fossil is observed to morph or give way going upward to more complex forms or new forms related but altogether different. At any level they can be sorted into categories according to their shapes or body plans. There are shells, exoskeletons, spicules, bone fragments, impressions, carbonized films, and other features that allow them to be assigned to the various phyla and flora defined by biologists for modern organisms. The upward changes in the types of fossils in any category are sometimes gradual and sometimes abrupt. Whole categories might disappear and be replaced with new ones. Categories themselves may incrementally change features as a lineage is followed upward in the succession. The very same vertical sequence of changes, disappearances, and new appearances occurs in stacked sedimentary layers all over the world.

This progression of life forms has been confirmed by generation after generation of international investigators for almost 200 years. It is not a theory but rather an observation as close to a fact as the observation that the Earth is round and not flat. It is occasionally challenged by those with religious agendas, but the basis of every such claim has so far been a blunder involving obvious contamination of samples or ignorance of how lower layers can be tectonically thrust over those higher up or even turned upside down during mountain building episodes. No, the body plans and characteristics of life forms have evolved with time.

This extraordinary evolution was explained by Charles Darwin and Alfred Russel Wallace as natural selection via “survival of the fittest.” Mutations occur, and those that give the organism an advantage thrive and multiply until the disadvantaged forms disappear. No one initially had serious problems with that theory until Darwin further claimed that humans were animals and thus emerged out of this progression. That created an outrage. Even today, polls show that up to 40% of Americans adamantly believe the biblical myth that humans were specially created by a deity and not by evolution. “Evolution” is not what they think. It is an observation of the fossil record and not the mechanism that caused it. Darwin’s proposed mechanism is open to debate. For example, detailed studies of the progression of fossils suggest rapid evolution of certain lifeforms followed by long intervals of no significant morphing and then sudden extinction. “Rapid” and “sudden” on timescales as lengthy as geologic time are awkward terms that could represent tens or hundreds of thousands of years

or more. The point is that evolution may not progress continuously, and extinctions may be accelerated due to climate change, habitat loss, or catastrophes such as widespread volcanic eruptions or asteroid impacts. Harvard zoologist Stephen Jay Gould eloquently promoted the ideas of "punctuated" evolution and "survival of the luckiest" to great effect. Studies of how and when mutations occur to provoke evolution are ongoing. Yes, the causes of evolution are still not understood, but it makes no sense to deny that it has occurred.

The fossil record is not obvious to us floating down through the layers, but it has been described, published, and confirmed by paleontologists who have thoroughly and extensively investigated the strata of the Grand Canyon. Using their results can open profound new vistas. Each layer is a window, or portal, into past worlds with strange creatures that differ as we go up or down the stack to younger or older times. The vistas opened by paleontology are not just about the nature and significance of evolution. Fossil treasures in sedimentary strata can make a time traveler of you. The Cambrian period we are now descending into started about 540 million years ago and is one of the most interesting in the history of life on Earth. It is the time not only of the first appearance of animal fossils but is also an interval hosting a wondrous expansion and diversification of body plans unlike any that followed. This extraordinary explosion of animal life lasted about 50 million years before new, substantially different lineages appeared. These new lineages evolved as notably different invertebrates along with vertebrates such as fish, plants, and land plants. Very few that originated in the Cambrian survived in later times. Those newly prospering lineages in the subsequent Ordovician period came to dominate the fossil record until the great mass extinctions that define the end of the Paleozoic about 250 million years ago.

The differences in the nature and abundances of various categories of Paleozoic life between Cambrian and post-Cambrian strata led University of Chicago paleontologist Jack Sepkoski to propose separate surges of evolution-- one that produced the "Cambrian Fauna" and the other to include the Ordovician up through Permian as the "Paleozoic Fauna." The Cambrian period is stratigraphically in the Paleozoic Era, so the second surge should probably have been given a different name by Sepkoski to avoid confusion. But there it is. Major extinction events occurred within the evolutionary surge of Sepkoski's Paleozoic Fauna. These have long defined the ends (and names) of the Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian periods. The great evolutionary saga of the Paleozoic Fauna is what we have just floated through going down from youngest to oldest, although the Ordovician and Silurian strata are missing in the Grand Canyon. We camped last night in the uppermost part of the Cambrian Muav Formation. The pervasive burrowing that produced that gnarly, knobby character was produced by the last survivors of the Cambrian Fauna still feeding furiously before they finally went extinct for yet unknown reasons.

Strange new canyon walls of the Muav Formation have risen out of the river after leaving Buck Farm Canyon. A half mile downstream we pass the difficult-to-see remains of a famous wooden boat that was being rowed in 1949 by 79-year-old Bert Loper. He flipped and

drowned back at 24.5 Mile Rapid, and his boat lodged here over 16 miles downstream (Fig. 11.1).

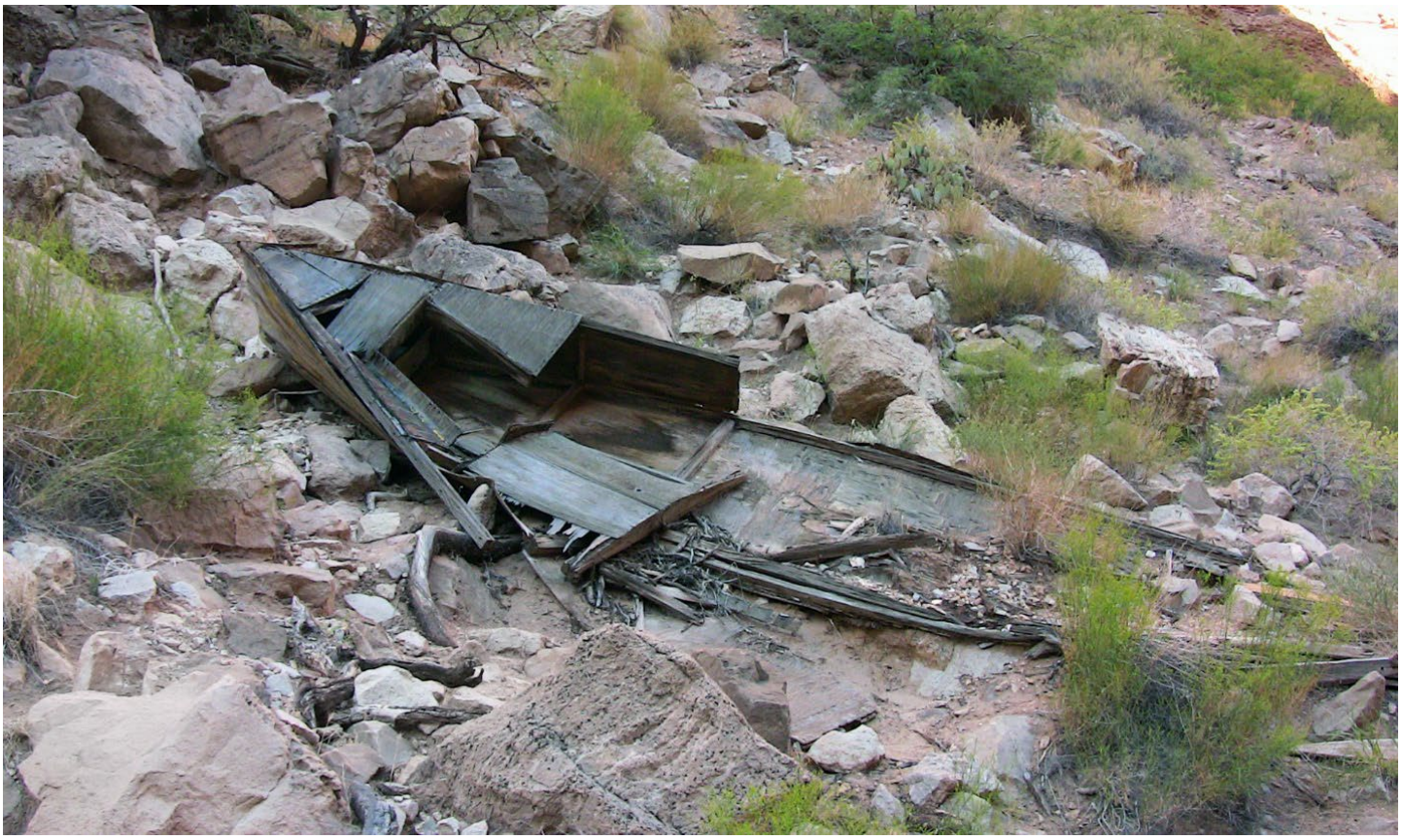

Fig 11.l. Remains of 79-year-old Bert Loper's boat that washed ashore over 16 miles downstream from where he flipped and died in 1949. He had been one of the first to row through the entire length in 1938 and returned for a second try when he drowned.

On a past trip or two, we stopped here to view what remains and take our hats off to someone that old taking on the Grand Canyon back when few would of any age would try it. He had rowed the canyon 10 years earlier and knew the risks he was taking. Things came out against him as still happens from time to time. A short trail up to a waterfall trickle with a scenic view takes off from here. We pass it all, although those who treasure river running view this as an important stop.

A dramatic alcove with interior shadowed arches peers down at us almost immediately (Fig. 11.2).

Fig 11.2
Royal Arches alcove at mile 41.7

It is the first and most striking of three that stand here almost side by side. Ground water is weeping out and staining the wall below. These “Royal Arches” developed toward the base of the Redwall/Temple Butte carbonates. Water coming down the fractures and caves in the Redwall may have ponded above a different fracture network (see below) or the more resistant dolomite of the Muav. Now it drains into the river which begins undercutting the cliff above. Or maybe the river during its downcutting slammed into the wall here where it turned east to form the huge meander loop we are now entering. It is the only meander loop of this sort in the Grand Canyon for reasons we can only speculate about. For whatever reason it is a new kind of scenery on the walls.

The boatmen immediately alert people to some scrabbly logs crossing a large crack high up in the Redwall on the right. Native Americans apparently found a way to come go up and down this high wall but needed to make a bridge which yet remains. Adventurous climbers are said to have found the route and crossed over the bridge. It is significant because on the other, eastern side of the river, a rubble zone of Redwall Limestone exists from the river to rim. It is a rare way to descend or ascend through the Redwall on the east side. Getting up the west wall was the problem, but that bridge means they did. This was once a river crossing for those ancient people who lived in this area. The rubble zone apparently formed as a landslide or by grinding along the "Eminence Fault." There is little evidence of displacement along this fault, but it doesn't take much to make a rubble zone. The fault may have affected the river course as it cut down through Paleozoic layers to form what resembles a rare meander loop. How that might have worked could be something to talk about over hors d'oeuvres with other geologists at the "Eminence Camp" where you can easily see the landslide rubble. A view down the river instead is more wonderful (Fig. 11.3).

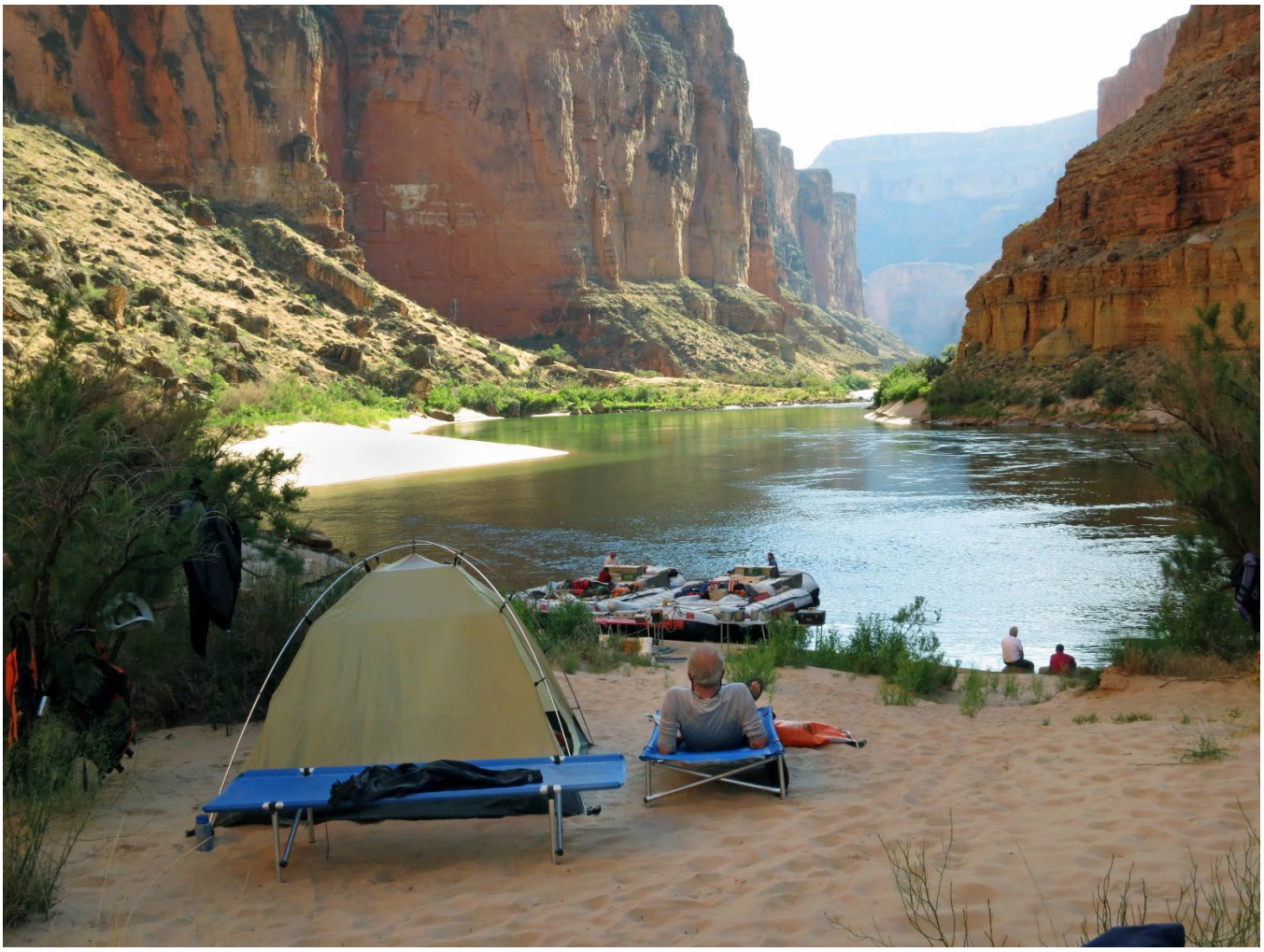

Fig. 11.3 View downriver from Eminence Camp. Luxurious camping.

Immediately to our right after running President Harding Rapid, the Muav Dolomite juts out unlike anything we have seen before (Fig 11.4).

Fig 11.4. Muav Limestone eroding out of the river walls as jutting pinnacles instead of smooth walls parallel to the river as is normally the case for the younger strata above. The Muav along with possible Ordovician and Silurian strata was uplifted and then eroded back down to sea level prior to deposition of the overlying Temple Butte and younger formations. The regional pattern of expansion joints in the earlier uplift was apparently different from those that developed in the strata deposited and uplifted later. The Muav is thus cracked in four vertical directions, two from the earlier uplift and now two additional ones from the latest uplift. Inasmuch as the river started its course at the highest levels, it originally tried to follow the latest regional fracture pattern but has now cut down into the lower set as well. The erosional shape of the river walls along this stretch thus reflects the tectonic history.

The erosionally-sculpted pillars with their smoothed facets suggest a more complex vertical fracture pattern in the Muav than what we have been floating down through the past two days. The change from smooth fracture surface walls to this is especially noticeable here for the first time. Some of the more ragged fracturing may be due to the nearby “Eminence Break Fault,” but the Muav is like this even far away from this fault which produced no major offset of the strata. I surmise that the geometric expansion cracks that developed during the pre-Devonian uplift experienced by the layers now emerging had a different orientation than that of the higher, younger set that guided the course of the river as it cut downward. If so, this

would support arguments that the Ordovician and Silurian strata were indeed present but were eroded away after an uplift event. The upper fracture set has been superimposed over the older one in the Muav. From now on, the river is trying to saw downward through strata that have two different sets of vertical joints-- four directions instead of two. So, the walls near the river become more complex as the lower set becomes more prominent. The strong cathedral-like ambience will gradually weaken downstream as these lower strata rise higher and higher.

After we travel three miles from Eminence Camp, more spectacular alcoves appear on the right. These are the "Triple Alcoves" that can be hit by the rising sun to shine with unique splendor (Figs. 11.5).

Fig. 11.5. Sunrise at Upper Saddle Camp looking upriver at one of the "Triple Alcoves" on one of the author's previous trips. Oldest daughter standing in foreground and all of us were transfixed by the stunning beauty.

These formed right where the big meander loop turns south. You get a visceral feel that the river earlier in its downcutting slammed into the wall here to make these big scallops. As the river completes its turn, we are in dark flaky mudstones with thin interbedded sandstones-- together known as the Bright Angel Shale. A distinctly olive-green tinge is often common in these rocks probably indicating the presence of a mineral called glauconite. It is an iron silicate

that forms abundantly around fecal pellets of burrowing organisms during the earliest burial history of the rock. Abundant glauconite is found in specific strata in specific regions up to the present day. It is especially prominent in many Cambrian strata. What is this telling us? North Carolina State University geologist Michael Kimberley discovered glauconite forming today along coastal Venezuela where iron-rich brines from the deep subsurface apparently discharge offshore. Are glauconite sands elsewhere areas where deep metal-rich continental brines discharged through coastal sands as Kimberley's work may indicate? There is so much yet to learn.

Saddle Canyon comes in from the west just after we come around the sharp bend. A large sand pile extending halfway out into the river has been dumped by outflow from this side canyon. A wonderful camp site extends from the river up to the top of this pile covered with mesquite trees and cacti that bloom gloriously in May. A long trail goes up Saddle Canyon past banks of lush ferns that line the gently flowing creek and ends at a beautiful waterfall that drops straight down about 25 feet (Fig. 11.6).

Fig. 11.6. Waterfall streaming over Muav Dolostone at the end of a long hike up Saddle Canyon at mile 47.5

That shady waterfall alcove is a great place to cool off and look at the intensely burrowed Muav Dolostone. However, we will have endless opportunities to see this remarkable display of early life that rampaged on the Upper Cambrian seafloor without first doing a long hike. More importantly, this campsite doesn't fit our schedule for this trip. We motor on past as I strain to see the big mesquite tree my wife and I once camped under with one of the greatest views on the river. Raft trips through the Grand Canyon produce memories that are never forgotten.

For me, the seven-mile stretch starting around mile 48 is the most beautiful part of the river corridor in the Grand Canyon. The steep walls of the Redwall have stepped back a bit to make things more comfortably wider and the rapids only bob us a bit as we pass over them (Fig 11.7).

Figs 11.7. Beautiful stretch of river between Saddle and Nankoweap Creek.

Someone has an urgent request for a pit stop, so we pull over and allow everyone to get rid of the coffee they borrowed at breakfast (Fig 11.8).

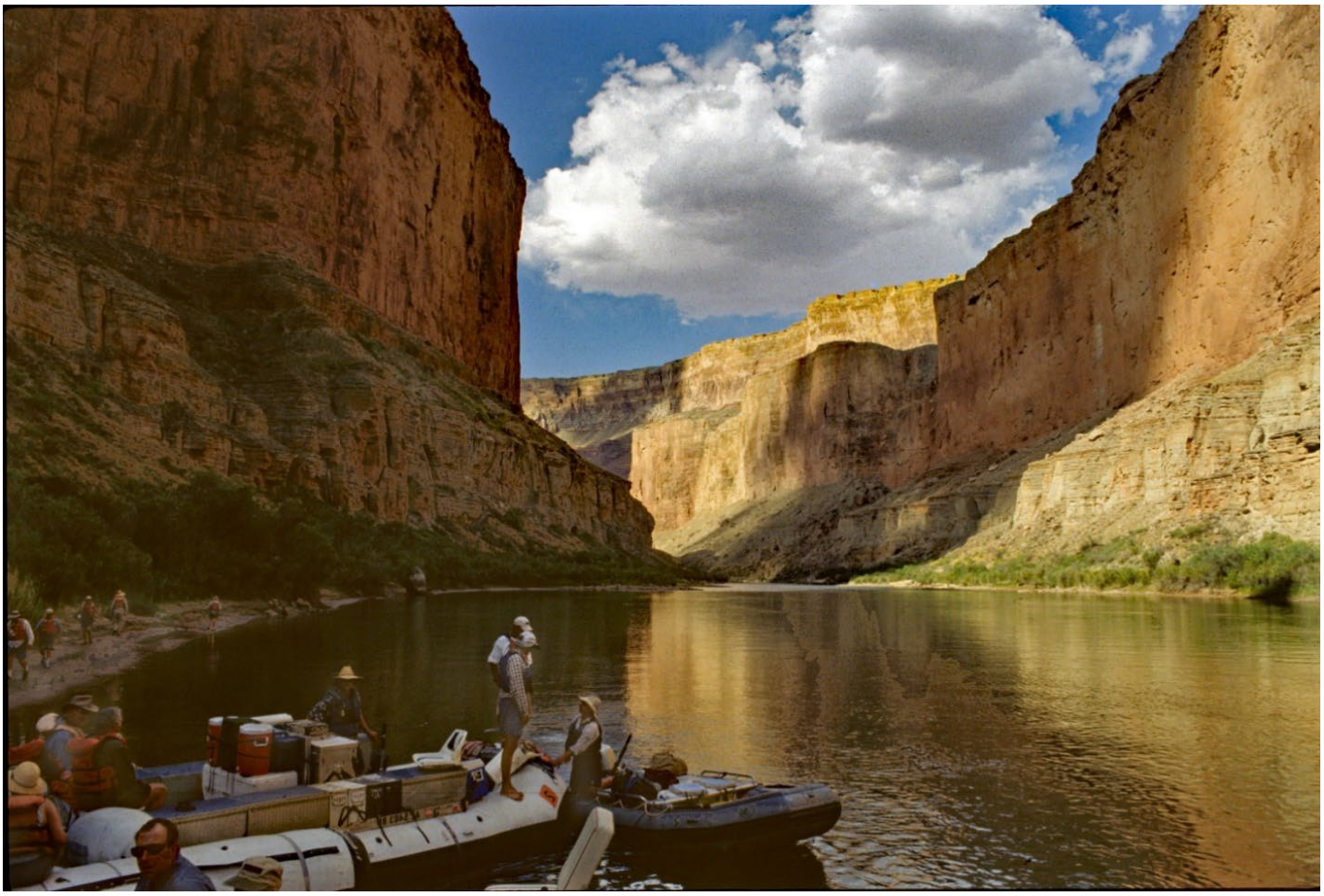

Fig. 11.8. Pit stop on placid waters.

The ladies walk upstream, the men down. This is an easy-to-remember practice based on the Rim-World practice of skirts up and zippers down depending on your sex. A private group pulls over and engages with our crew in the usual river chatter. I suspect this is the last stretch dominated by walls dominantly split off with the upper rectilinear fracture pattern and explain that to some gathered around while we wait for everyone to return (Fig. 11.9).

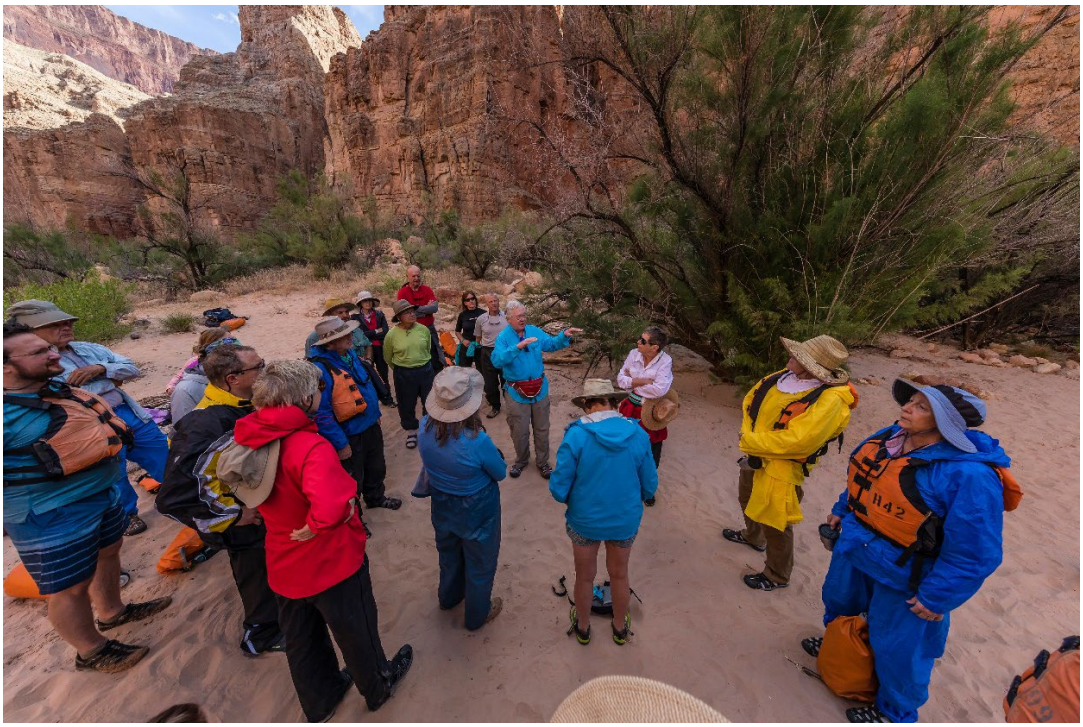

Fig. 11. 9 The pilgrim arm waves a geologic story. (Image courtesy Michael Nolan)

After shoving off, we turn off the motors. I ask for everyone to go completely silent for about 15 minutes—no jabbering, laughing, or moving around—just silence (Fig. 11.10).

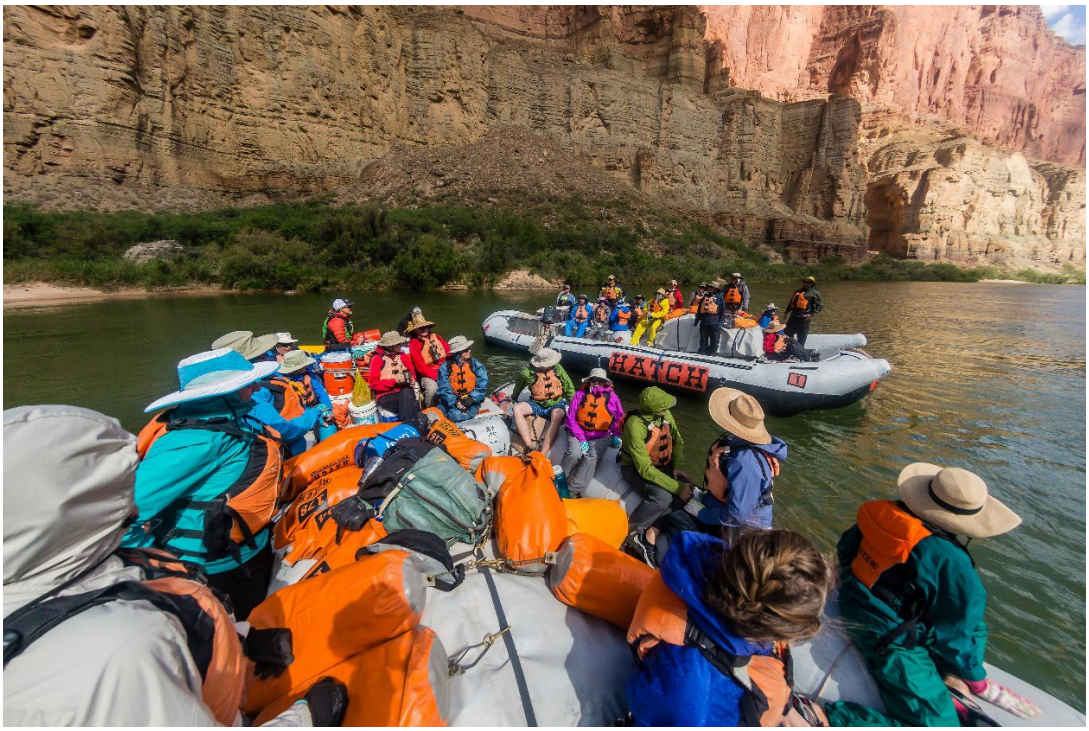

Fig 11.10. Silent running. No talking for about 20 minutes to listen to the natural sounds. (Image courtesy of Michael Nolan)

We lazily float along hearing bird songs in the lush vegetation along the banks. The sweet sound of the Canyon Wren is magical, but on this trip, I am alarmed again at how infrequent it has become over the past decade. Is the most beautiful sound in the world now vanishing from the Canyon? The river gently churns, swirls, and gurgles. Sunlight penetrates gaps in the walls to make brilliant gold patterns amidst mystical jet-black shadows above the green glow of the river. How I love these silent intervals where your soul seems to intermingle with the gentle pulse of time and the river flowing. A passenger once told me that among the surfeit of high points on her trip, this brief hush was one of the best. For me, the silence is almost mystical as the Cambrian strata slowly emerge above the riverbanks. We are in it—the amazing Cambrian with its earliest explosion and radiation of animal life. We, the most evolved consciousnesses in the history of animal life ascended via a tortuous evolutionary path from Cambrian strata. Here we are--slipping silently down into the home of our earliest evolutionary ancestors. I once thought it was special to pass the hospital in Houston that I was born in. But this!

The distinctive sound of an upcoming rapid slowly displaces the silence, so we power up and pull into a tiny landing spot at mile 52.3 soon to be overgrown with tamarisk. A gigantic pile of rubble lies straight ahead forcing the river to curve around it against the left wall. It is a pile of debris-flow blocks, boulders, sand, and mud that came surging down Nankoweap Canyon entering here from the right. The is the biggest outwash pile we have encountered and is called the “Nankoweap Delta.” It is not really a delta in the sense most geologists use the term. Deltas normally form in an entirely different way in an entirely different setting via an entirely different set of processes. But “delta” we will call it. Nankoweap is a long, wide side canyon with an extensive, elevated watershed upstream. The debris flows surged out across the river and piled into the steep left wall time and time again. The piles are so high that the river has hardly begun to wash them away. Instead, it cut a channel around their lower ends against the left wall. The huge pile of debris has forced the river to flow around it and thus saw into the base of the left wall. At intervals, the overlying cliff face collapses and contributes to the rubble. Flow in an arc around the bend erupts into one of the longest rapids in the Grand Canyon. While long and technical for the boat drivers, it is not that much fun for the passengers. That is good because this group is going to walk over the delta while the boats go on around the bend.

Although I am anxious to talk about the Cambrian, geology is only part of the reason for the stop here. It is time to do an easy hike over this cosmic heap of rubble now covered with sage, burro brush, Mormon tea, bunch grass, prickly pear, barrel cacti, and 34 degraded arrays of piled-up rocks that were rooms and kivas constructed by Native Americans who farmed and lived here over 1,000 years ago. Nankoweap Creek is a shallow babbling brook flowing along the upriver side of the delta. We disembark and hike up rivulets of this stream as they thread their way around cobbles and strung-out heaps of gravel. Splashing along in the cool water, we converge in deep morning shade created by an isolated cliff face of dark Bright Angel Shale (Fig 11.11).

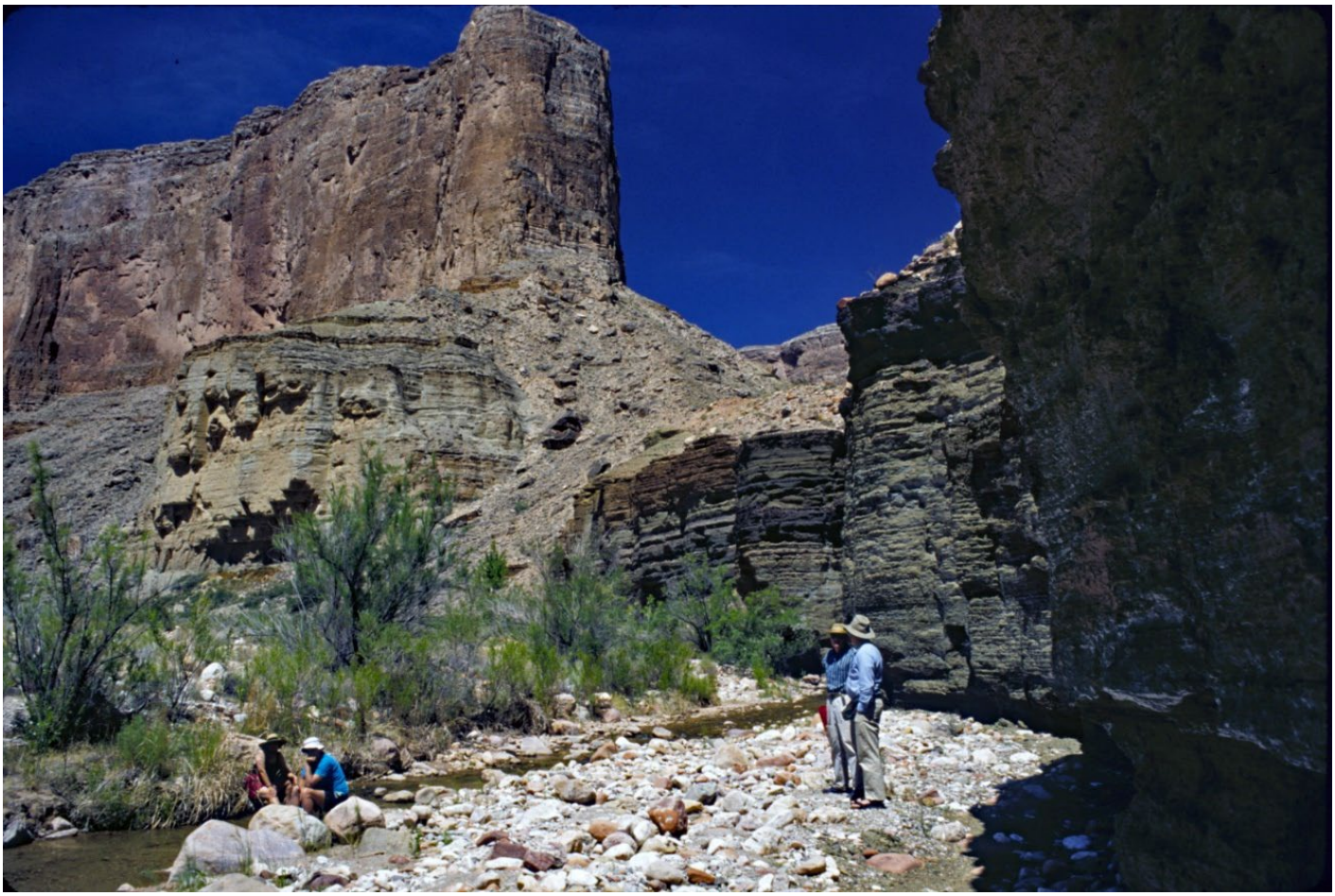

Fig 11.11. Cliff exposure of the almost black Cambrian Bright Angel Shale in Nankoweap Creek about ¼ mile from the river. The steep cliff on the skyline is the Redwall Limestone. The bluff below it is the Muav Dolostone. The thin Temple Butte Limestone lies between the two but is not visible from this viewpoint.

Shale turns to muck after long exposure to rains, but here a fresh vertical wall stands intact. Over time, the creek washes against the lower part of the cliff to make an undercut. Soon, nothing is holding up these fissile, flakey little black ledges. During a heavy rain and/or high water flow, the whole cliff face suddenly sluffs off leaving a pile quickly redistributed downstream. Left behind is a strikingly fresh exposure of the shale--better than any possible on a sloping surface where everything turns mushy before finally washing downhill. We take the opportunity to briefly look for fossils on the fresh shale flakes sticking out of the wall and about to fall off. Notable examples of trilobites, everyone's favorite fossil, are found in the Bright Angel Shale elsewhere in the Grand Canyon. Why not here? It is rare to find complete fossils of these multi-legged creatures, although the cephalons (heads) and mixed body fragments known as trilobite "hash" are commonly found in certain layers. We do not find good examples in this exposure, but it is a great spot to discuss the Cambrian. So, I do.

Looking closeup at the fresh face of a little exposure of nondescript black shale is apparently not particularly inspiring to the group even though I tell the remarkable story of the Cambrian Fauna. It is usually a bad idea to show people something they cannot see, and the

lure of indeed seeing Native American ruins draws their attention away from my jabbering. So, I end and turn them over to JP who will lead the charge over the delta. Two of the crew are driving the boats around the delta to a landing spot downstream where we will rendezvous after the hike. JP will lead the troops up the trail to several of the rock piles on the delta arranged in rectangles upon which Pueblo People from around 1000 CE (AD) erected poles and skins for wind and foul-weather protection. The smooth floor areas from which the rocks were extracted make the sites easy to spot on this otherwise rough walking surface. Our plan is to visit a few of these degraded ruins, enjoy the view, and then ascend a steep trail to a place where rock walls were built in front of shallow erosional indents in the Redwall Limestone cliff face. Their purpose remains unknown, but they are called “granaries” from the likely possibility that these were used to store grain grown on the delta (Fig 11.12).

Fig 11.12. Geologist Extraordinaire Donald Burt at granaries high up on cliff above Nankoweap Delta.

It is certainly a possible place to store a food supply away from pesky rodents. I have a slightly serious hypothesis that they were mainly a place to get away from cedar gnats, which can drive a person insane here at certain times of the year. This is one of the few archeology stops we will make. It includes an iconic view downriver from the granaries that shows up in ads, books, and airplane magazines (Fig.11.13).

Fig. 11.13. View south downriver from granaries above Nankoweap Delta. Huge amounts of gravel derived from the delta are being pushed downstream by the river. Sands pile up as projections from the banks and as bars out in the river for about a mile downstream. The rafts near the bottom of the image are at mile 53.3.

The crowd eagerly scampers up a trail over the delta leaving me standing alone in the shade of this freshly cut cliff face of dark crumbly mudstone.

The gently flowing water that is barely ankle-deep slurps and gurgles over colorful cobbles, and I find myself in splendid isolation. O beata solitudo, o sola beatitude! I love all these people, and I love expounding about geology and what it might mean. However, these moments alone are a treasure. I am free, so I instinctively pick around futilely for a good trilobite. This is something every geologist does when facing Cambrian shales. A good trilobite locality is for a geologist on a mission what a sand trap is to a golfer. Wherever you are headed, you will compulsively stop at a good Cambrian shale locality, pick out thin flakes and slabs, be mostly disappointed, and throw them over your shoulder. They are the iconic fossil for most people but finding a complete one is a rare thrill. I know I cannot collect them in a National Park, but are there any here to admire?

Cambrian strata are the oldest that house extensive fossil evidence of earliest animal life. I stand in a shady spot and stare at this dark wall made jet black in the shadows. Questions that have gnawed at me for decades begin raging. Why did animal life first evolve so late in Earth history? Sedimentary structures likely made by microbes as well as microfossils themselves have been found in rocks at least 3.5 billion years old. Yet animals do not appear for another three billion years. Was it something about the conditions of the surface environment or is animal life so complex that it just took it this long to evolve? If it is a complexity issue, why then did animal fossils so "suddenly" appear in marine sedimentary rocks across all the major phyla? Yes—the eye of geologic time blinked and here arrived all the animal phyla with chitinous coverings, carbonate shells, phosphate shells, and opaline spicules—all within a few million years as far as can be determined. All in lower Cambrian strata about 540 million years ago. While rare forms interpreted as possible animals have been found in the latest Precambrian strata, the Cambrian itself was a veritable explosion of animal life. There are many suggested explanations for this, including a unique and obvious one I published involving a tremendous reduction in ocean salinity at this time. It has gained no traction so far. None proposed ever have. I will confront this enigmatic arrival of life in the sea in a profound way and reexamine the issue during my upcoming traverse through Death Valley. Best not to think about it now. The Cambrian is a long time-interval, and we will not encounter the lowest part of it on our raft journey because Arizona was apparently a land area at that time. Before the day is over, I hope to explain all this to the crowd. But now, I am lost in other thoughts about the Middle Cambrian world that produced this black shale.

A few miles west of here in Nankoweap Valley where this stream originates, the great paleontologist Charles D. Walcott camped for 10 days in 1882 and explored the strata for signs of earliest life. He explored all over the west on long horseback traverses in areas few had ever set foot in. He somehow managed to find many of the most crucial outcrops to this day that display evidence of early animal evolution. One such discovery was in the Burgess Shale on the slopes of the Rocky Mountains in British Columbia. It is claimed a horse in front of him kicked over a slab of coherent shale and flashed a fossil with unsurpassed preservation. He

started excavating there, and such excavations have continued to the present day. For at that locality, a slump of mud on a sloping ocean floor in the Middle Cambrian had instantaneously wrapped up communities of organisms going about their business. There was no warning and all living there were jumbled together into a matrix of mud which was sealed off from oxidizing bacteria, bottom feeders, and later burrowers. Walcott had discovered a rare locality with extraordinary preservation. It is a remarkable snapshot of daily life on the Middle Cambrian seafloor, possibly now the most famous fossil locality in the world. Walcott described and classified many of the fossils he excavated there during the winter months in his lab in Washington DC. The most famous of the later studies and their significance is by Simon Conway Morris who spent decades in his own lab carefully scraping, brushing, and micro-excavating specimens from the Burgess and other localities to help reconstruct the actual appearance of the soft bodies of animals in the Cambrian seas. The results captivated and inspired zoologist Stephen Jay Gould to summarize for the public the nature and implications of these life forms. He reckoned in his wonderful book, "Wonderful Life," that evolutionary experiments were exceptionally rampant then with only a few body plans surviving--not so much because they were the fittest, but because they luckily survived all that can cause extinction. His illustrations show fantastical looking organisms with complex forms and appendages never existing since. Even trilobites look humdrum compared to some of those illustrations. Subsequent work had to pull back a bit on just how fantastic these critters looked, but not by much. Most of these were extinct by the end of the Cambrian. There was a huge pulse of animal life that evolved, radiated, and diversified in the Cambrian and then was no more. Some of the lineages did survive and evolved further in the Ordovician and ever after, but this great explosion, burst, and celebration of new life in the sea was over.

Gould suggested that this climax of experimentation in body plans and diversity in the Cambrian was the greatest in the history of evolution. As a zoologist, he disputed that humans are the pinnacle of evolution. While he may be right in terms of body plans, some disagree because there has never been an integrated nervous system or brain in any organism to match the one in humans. The electronic activity and control of physiological functions in humans is probably now more complex than in any organism in Earth history. Our brains are now even linked via the internet into a neural network spanning the globe wirelessly. Nervous systems have evolved over time, and we are the supreme culmination of that.

Conway Morris disagreed with a major point in Gould's book that if the tape of evolution were rerun, evolution would not likely produce the same result again because it is guided by so many chance events. Instead, he published his own book arguing that biological features eventually converge on patterns optimized for the environment and that other such environments elsewhere in the universe could likely host creatures like those on Earth today. An everyday example that might support this view is the evolution of automotive sedans. To minimize fuel consumption, designers needed to minimize aerodynamic drag. That turns out to be basically one shape, so the various brands have converged so much that it is often difficult to tell a Ford from a Toyota. Examples in the biologic world are legion with respect to

vision, hearing, swimming, and other traits. However, the diversity of extant organisms seems endless and new varieties of life are continually being discovered. Much of this variety is undoubtedly the result of "survival of the luckiest," so what are the odds the animal world would resemble the current one if evolution were rerun? And what about other worlds in the universe where environments and their histories could be utterly different? Studies of the Burgess Shale have thus contributed to a firestorm of thought relevant to these larger issues. Not knowing who is on the right path about those issues does not bother me standing here this morning in the cool creek waters. For now, I have become fixated on this fresh cliff exposure of Middle Cambrian shale. Emotionally immersed in it!

Informed by the labors of all the indefatigable paleontological greats, I stare into the darkness of these shadowed layers in silence except for the entrancing sound of shallow water rippling gently over gravels. These shales are the actual materials deposited on the sea floor during this epic time of evolution—right here in front me! Using what science has revealed, there is a chance to touch, connect, and merge with an important world that once existed at this very spot. To transition into that world, I willfully imagine something akin to the last scene of the movie "2001." Colorful streamers emerge and start zooming past me. Like the space traveler in the movie, I am drawn into another dimension. I am immersed in and witness to life in the Cambrian Ocean as envisioned by science. Amidst sun rays penetrating clear blue waters, colorful creatures with strange shapes are passing by and scurrying around the muddy bottom (Fig 11.14).

Fig 11.14. Cambrian life in the sea. Anomalocaris is the large predator with curved appendages. Obinia with its single appendage is the swimmer near the bottom to the left. The walking worms are Hallcigenia. Sponge colonies armored with spicules are to the left of center. (Dotted Zebra/Alamy Stock Photo)

Clumps and strands of green algae are waving back and forth as small waves oscillate overhead. An Obinia with its weird dangling appendage hovers over colonies of early sponge-like creatures while trilobites rummage and scrape to ingest organic goodies falling in from the life battles around and above. And there is a walking worm, the amazing Hallucigenia. A giant segmented Anomalocaris approaches slowly propelled by two long undulating fins running down both sides. Large round eyes at the ends of two flexible stems peer and see. Two long appendages with serrated edges move to and fro to grab prey and pull it into a round mouth that looks like something from a horror movie. Numerous fingernail-sized iridescent arthropods known as Mirrallae scavenge in the muck with their curved-backward spines and alert antennae busily dithering and flicking. Small eel-like swimmers called Pikeia weave through the algae above little caterpillar-like Aysheaia confined to the murky bottom. All these creatures unique to the Cambrian world burrow, crawl, ruck, dart, swim, and soar--the shallow waters are seething with animal life. Protruding eyes roll around ceaselessly scanning up, down, and side to side. Bodies suddenly freeze and cinch ready to dart away or pounce. Anything seen is either food, foe, or a potential mate. Alarm! This is not an altogether pleasant scene. A blast of turbid water sprays up from the bottom after a swimmer descends, attacks a crawler, and emerges with its prey writhing in agony. A swimmer encounters long tentacles hanging from the fragile, transparent, bell-shaped body of a jellyfish. The flexible bell pulsates

while the prey jerks and becomes paralyzed from the awful stings. The tentacles twist together and bring the victim up into its mouth where it quivers as it is slowly digested alive. There are predators here and predators there, and they are indifferently attacking and eating each other with horrendous, life-ending violence. Here is animal life in all its glory and all its terrors. I recoil at the amount of pain involved. Gruesome. Horrible! No more of this! Poof goes the vision, and I am standing before a cliff of mudstone near the mouth of Nankoweap Creek. Science took me back to see daily life in the Middle Cambrian Sea. Comprehension of the fundamentally violent nature of animal life brought me back.

Animal life requires energy supplied by the sun. It must eat organisms like algae and cyanobacteria that synthesize energy-rich organic matter directly from its light--or eat other organisms who eat the photosynthesizers. The Cambrian explosion of animal life initiated a path of ruthless predation and inconceivable amounts of pain. Darwin consoled himself that suffering of prey in the grips of a predator is brief. Yes, but that is only for one organism. Every second of every day, billions of animals are subjected to life-ending savagery. Cumulatively, the pain and agony on this planet over 540 million years is unimaginable. The beauty of animal life is intertwined with never-ending horrors. We always look the other way, but sometimes a pilgrim must look the devil in the eye. This is the path that evolution to human consciousness in animals took on our Earth. It began accelerating while these very layers of ancient mud before me were accumulating. This evolutionary scheme toward consciousness cannot be bad…cannot be good. I reach out, crumble off a few bits of gritty shale, and rub them between my fingers. Sprinkles that were once actually part of this ancient world fall downward into the creek. They are chips that were once witness to the earliest flourishing of animal life and the scene I just envisioned. Every flake of this hardened mud probably even passed through the innards of a burrower or predator. Now these flakes with all their stories will be washed down Nankoweap Creek to the river and eventually into the sea where it originally accumulated over 500 million years ago. Is this the only way consciousness can arise in the universe? Really? Is this the only form of consciousness that exists? Created in such a horrific way?

Those who ponder the effect of great art works have written volumes about how art can arise from and communicate with the “inner person” – with domains of the conscious and subconscious that respond to symbols, trigger buried memories and longings, or even tap into a collective psyche. All of that is subjective and concerned with untestable notions and internal aspects that vary from individual to individual. Consciousness is so mysterious, but I reaffirm that science can also penetrate emotions of the inner self. It is a basis that deals not with symbols, intuition, and trust in the assertions of others. Right here we have the tangible ocean sediment before us and a tentative understanding of the world and its life at the time it was deposited. We also have a likely grasp of where it fits into the overall evolution of life. It is not symbol or cultural history that communicates with a soul contemplating its meaning. It is reality, even if that reality is not known with certainty-- and never can be. It is an interpretation, a human construct based on forensic examination by careful investigators who

vet and filter in response to peer reviews and objective debate. It is meant to be the most likely representation of past truth. Yes, art is powerful and enriches our lives. Remarkably, a mental trip into an outcrop like this can produce an experience as overwhelming as any artistic creation. For better or for worse. It just did for this pilgrim. A little exposure of dark shale and I experienced the dark side of the Cambrian. Of course, all this may simply mean I am weird. So be it. But wait! All my rafting companions are long gone from here. I need to end these musings, quit these fantasies, leave the Cambrian world, and go catch up with the group.

Not aware of how much time has gone by, I rush up to the ruins at the top of the delta. My troops, my soldiers of science, are now soldiers of anthropology and have already departed for the climb up to the granaries. Some are visible as little ants going up a steep switchback trail to the little row of window dots in the granary walls. This promontory of piled up debris flows has views upstream, downstream, a giant curving wall across, and one up the valley of Nankoweap Creek. To the west visible for the first time, a forested plateau forms the skyline much higher than that which we have seen previously. It is the east side of the Kaibab Uplift where the strata we just floated down through are over there about a thousand feet higher in elevation. We had been approaching this, but the river has bent to the south and is now running parallel to the east sloping side of this "half watermelon" (Fig. 2.1). If we were to hike up Nankoweap Creek we would expect to see the nearly flat-lying Bright Angel Shale turn into a ramp that starts sloping up the eastern side of the uplift like the one I drove down from Desert View. Instead, we would find that any such ramp has been eroded into a peculiar valley trending south parallel to the present course of the river. The uplift being a thousand feet higher, we would expect to find rocks in this valley that lie stratigraphically far below the Bright Ange Shale. Sixteen miles south from here the river will make an almost right angle turn to the west and carve across this big valley; there is no need to hike up Nankoweap Creek to encounter those rocks. I mentioned none of this to the group because I plan to take everyone tomorrow on a hike into that valley wonderland.

Looking at the low rectangular rock walls that the ancient pueblo people piled up atop the delta, I reflect on the levels of awareness that have recently evolved as science has progressed (Fig 11.15).

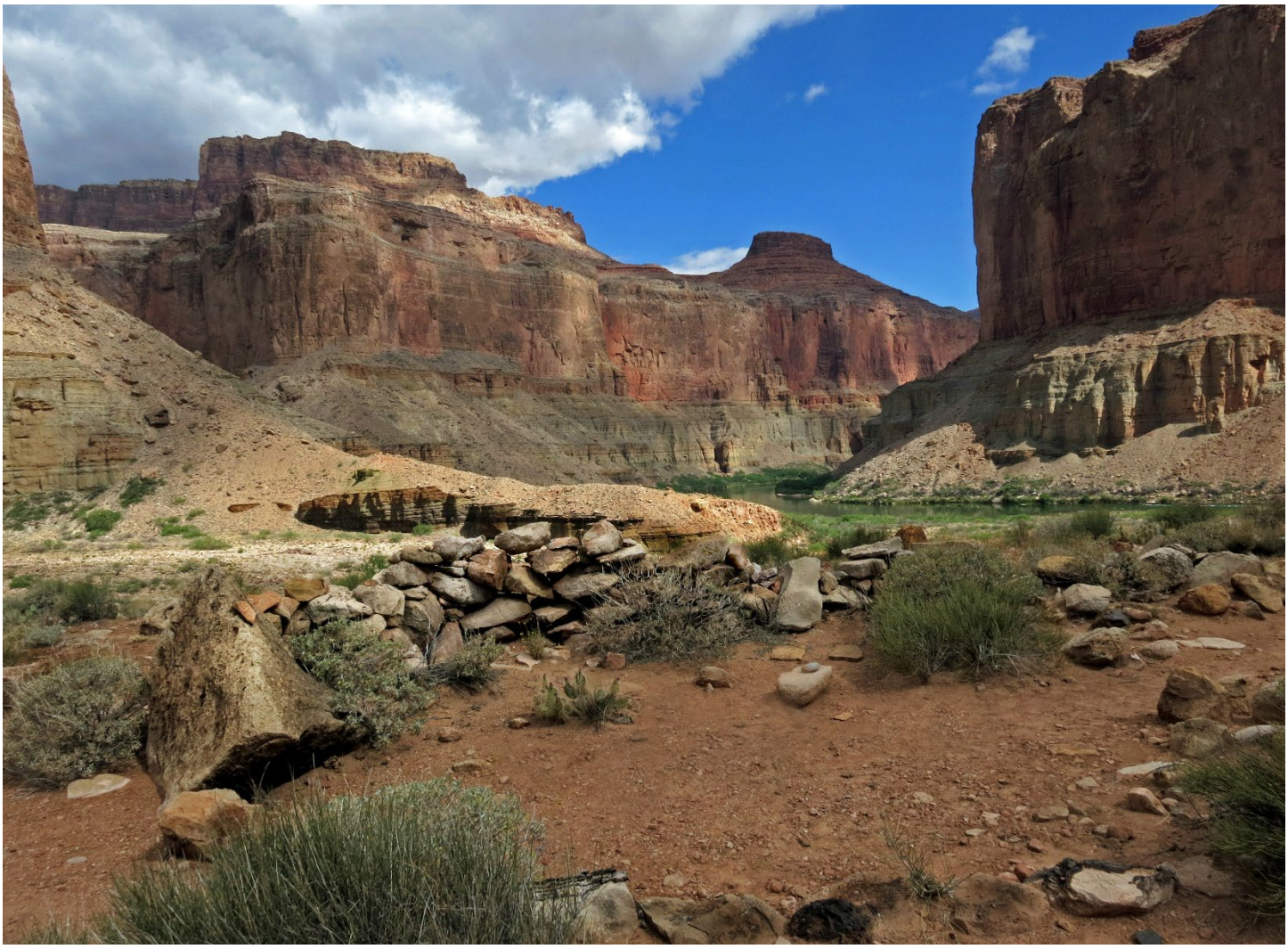

Fig 11.15. View north from Indian ruin atop the Nankoweap Delta overlooking Nankoweap Creek entering from the left. Large rocks were removed from the central area to make the low walls. Skins stretched over poles likely provided foul weather protection for narrow parts of the structures.

Human consciousness may or may not have advanced much morally and spiritually, but our ability to see aspects of the world from places like this have developed spectacularly in the last 200 years because of science. The builders here were occupied with survival amidst unpredictable nature and predatory aspects of their fellow human beings. They had to grow crops, defend them, and endure cedar gnats. There was no recognition by them that the wall rocks they piled up here were once seashell fragments on an ocean floor. They certainly had no chance to soar through a Cambrian cosmos of extraordinary organisms while they filled water jugs in front of that black cliff of Bright Angel Shale. I am sure that was the filling spot because the path connects these ruins right back down to that dark cliff. It is the closest spot to get water. The Indians made this trail we walked up! Children no doubt splashed right there under the watchful eyes of mothers standing exactly where I stood before they had to lug water back up the hill. I once did field work in the Barberton Mountains of South Africa in sight

of a large clump of thatched-roof dwellings about 200 yards from a spring. Women and children carried water jugs back and forth in an endless procession all day. It is easy to visualize the same here. They did not and could not then know the scientific fantasies that can body forth from a small wall of Cambrian shale.

On the other hand, that same lack of awareness is still the condition of most of modern humanity as it rafts past here. So, I better shake off my free-time mental ramblings and get across the delta to the boats now pulled in at mile 53.3 to pick up the anthropology soldiers. There are souls hungry for science—or at least for lunch. In my rush and daydreaming, I miss the turnoff to the beach and get lost in a trail mishmash weaving through mesquite thickets. Cursing and swearing, I finally find the right path and arrive just as the granary climbers are climbing onto the boats. We are running late, so there is no geology spiel here. A good place for lunch downriver awaits. Count off and let's go!

As we pull out, the Goddess of Nostalgia makes a visit. I lay back against the duffel pile, watch pinnacles and cliffs float past, and get flooded with memories. This stretch was the first time I floated on the river. About 40 years earlier, Tulane professor Bob Horodyski, ASU undergraduate assistant Pat Lowry, and I backpacked down from the North Rim into Nankoweap Valley and camped in the trees at Wolcott's historic camp site beside the creek (Figs 11. 16, 11.17).

Fig 11.16. Hiking into Nankoweap Valley along an old Indian trail from the North Rim. The trail has degraded but is still used by us backpackers who must carry inordinate amounts of heavy water.

Fig 11.17. Camping at Walcott's 1882 campsite in Nankoweap Valley where he explored for the earliest evidence of animal life. The strata were some of the last deposited prior to flooding of the area by the Cambrian Sea. No fossils attributed to animals have been found here, but bacterial mounds of laminated carbonate and microfossils of likely unicellular organisms are common. Although previously assumed to be marine, some us feel that these particular strata are more easily interpreted as lake deposits.

Indians had once lived there as well (Fig 11.18).

Fig 11.18. Backcountry Indian ruins are abundant in areas of the Grand Canyon near water sources. Few have visited this example in Nankoweap Valley. It is one of many littered with colorful potsherds and grinding stones. It is always a thrill to come across these places which were occupied around 1000 AD.

We were collecting rocks as part of separate research projects. Horodyski had arranged a rendezvous with a Hatch raft trip run annually by Tulane University that would supply us with victuals, take our rocks out, and transport us down the river to Hance rapid where we wanted to do more work. After four days of eating freeze-dried food, climbing impossible slopes, lugging rock samples in our backpacks, and wading three miles down Nankoweap creek, it was sheer heaven to climb aboard a raft. I lay on a sideboard with my back on the duffel pile and legs stretched up on a pontoon. Someone gave me a beer even though it was about nine in the morning! As we floated along, I watched the surreal scenery drift effortlessly by, got woozy, and fell in love with this kind of rafting. I vowed to do it again but had no idea then how many such trips I would make in the future and what it would come to mean to me. Seven years later, on a raft trip with students, I brought supplies to Horodyski and picked up his rocks right here. He was working again in Nankoweap Valley, but this time had hiked in by himself. He would work another day here and then hike back out. He gave a short talk to the students about what he was looking for, and we pulled away (Fig 11.19).

Fig 11.19. Geologist Bob Horodyski giving an impromptu talk to raft trip participants next to the Nankoweap Delta. He had backpacked alone down from the North Rim to do field work in Nankoweap Valley again. Via prior arrangements, we brought a supply of food and took his rock samples for shipment to his lab at Tulane University. The prominent cliff is the Redwall Limestone with paleokarst along its top beneath the dark red Supai Formation sands and shales.

As he stood there waving and shrinking in the vastness, a visibly emotional student turned to me and said, “That was awesome. This guy…out here working all alone…WOW...I always wanted to meet a real scientist.” I looked at him, recoiled, and frowned. He suddenly realized he may have inadvertently offended me. Before he could say anything, I blurted out in support, “You’re damn right that’s a real scientist!” And that he was.

The river we motor out onto here as I wallow in nostalgia is wide and shallow as it streams over sheets and bars of gravel. It is struggling to push the enormous amount of rock rubble that was dumped in from the Nankoweap Creek debris flows. The gravel finally submerges downstream as does my poignant memory of Bob waving goodbye, the ancient people who were also specks in the vastness here, and the Cambrian Fauna in which the long evolution toward consciousness in animals began to accelerate. Science is slowly starting to understand how this incredible event happened on this insignificant speck in such a vast universe. Does it really take 4.5 billion years and environmental conditions like we have on Earth to happen? The oceans and atmosphere are films so thin that if we shrunk the planet down to the size of a basketball, we could not even feel those films. Evolved here? In that? Really? Only in thin films on insignificant Earth-like planets in this otherwise vast cosmos? Can we understand why it happened? Must it be? Many puzzle and fret over life’s origin. They develop ideas, beliefs, and prejudices but so far-- no answers. Much has been written. But what do the rocks themselves indeed tell us about this? I just tried to connect with some dark shale and encountered the dark side of the Cambrian. It raised new and challenging issues that never disturbed me before. It is only day five of the pilgrimage--or whatever this is turning into.