Chapter 23 STEER FOR THE DEEP WATERS ONLY

The planned pilgrimage could be done as a single journey, but that is hardly advisable. The optimal time to raft through the Grand Canyon is mid-May before it gets too hot and before the summer monsoon rains muddy the water. Emerging from the canyon toward the end of May means that the journey across the deserts of the Great Basin and into Death Valley will be during the hottest time of the year. The only thoughts would be how to get through it comfortably-- or at least alive. Camping would be out of the question. So, at this point of the journey, I break off to head back home to Phoenix. I will return in the coming winter when the desert climate is perfect, and the lighting is magical.

Departing from the boat landing, the road first goes up to the top of Grapevine Mesa, a plateau about three miles wide and 18 miles long running almost north to south. The roadcuts show that its north end is mostly made of brown mudstone layers overlain by a gnarly gray limestone. These are new layers and certainly not extensions of the Paleozoic layers we just emerged from. Reaching the top, I cannot resist turning left and driving back on a dirt road that leads to the north cliff edge of the mesa for one of the grandest views in the southwest. There is the mouth of the Grand Canyon, the western face of the Colorado Plateau, and a first view of the "Basin and Range Province" that has utterly different topography. Lake Mead once extended to here but is currently shrinking due to drought (Fig. 23.1, 23.2).

Fig. 23.1. Mouth of the Grand Canyon at the Grand Wash Cliffs when Lake Meade was nearly full.

Fig. 23.2. Mouth of the Grand Canyon after water level of Lake Meade had dropped significantly due to drought.

The formerly submerged river channel is now cutting deeply into the sediment left by the retreating lake. And then, low to the north in this valley known as the Grand Wash stands a sight to behold in wonder. It is the red Supai Formation which adorned so much of the scenery high on the walls of the Grand Canyon—but see you! It is at a lower elevation than before and is tilted almost onto its side (Fig. 23.3).

Fig. 23.3. Wheeler Ridge is seen here looking north from the north end of Grapevine Mesa. The Colorado River is visible to the right of center at the base of the sloping beds. The slanting red layers are the Supai Formation in a block that cleaved off the western edge of the Colorado Plateau about seven miles to the east. The northern extension the Colorado Plateau escarpment is in the upper right part of this image.

A whole block of it named “Wheeler Ridge” has apparently cleaved off the western edge of the Colorado Plateau and rotated down to the east. This is no landslide; look how far it is from the cliff it was attached to! Could it have tilted and moved westward five miles? This would require it to have rotated downward along a nearly vertical fault plane that then curves nearly horizontal at depth. One interpretation invokes adjacent but now buried tectonic blocks that might explain what happened here (Fig 23.4).

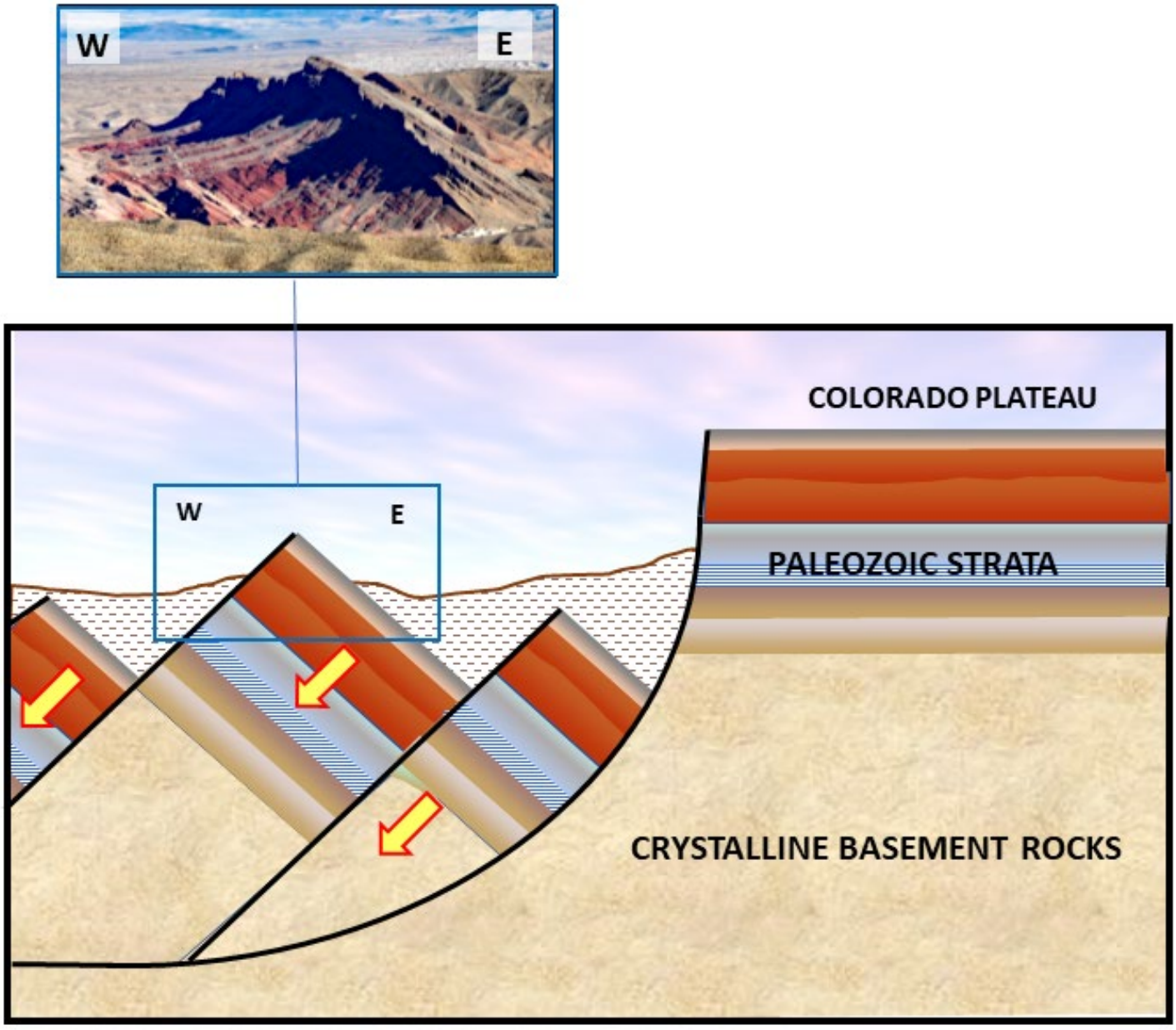

Fig 23.4. Simplified conception of how fault blocks like that of Wheeler Ridge cleaved off the western edge of the Colorado Plateau at the Grand Wash Cliffs. Sediment from erosion of the peaks has blanketed the blocks leaving only Wheeler Ridge protruding above. The number, size, and actual geometry of the faults and blocks could be quite different from this cartoon. The idea of a vertical fault plane that curves and flattens at depth is used throughout the Basin and Range Province to help explain the jumble of tectonic blocks there.

The uppermost parts of the Earth's crust extending west, north, and south of here are made of innumerable blocks that appear to have been rotated, uplifted, dropped, thrust over one another, split into parts, jostled, displaced laterally relative to their neighbors, invaded by molted rocks from below, and blasted from underneath with explosive volcanoes. The

geology of these regions will involve an entirely different and dizzying way of thinking about geology. The sights and thoughts of these things flabbergast and excite me after travelling for days in geology that now seems simple. I am tired mentally and physically from experiences of the last 24 hours and still have a long way to go to get home. I cannot linger here. Instead, I will return later to this place of wonder and then plunge into the next leg of my pilgrimage—or whatever this journey has become.

Back on the paved road and four miles to the south, some pull-outs to the right provide great vistas from the western edge of this mesa. l stop there adjacent to a pavilion to wash up, change clothes, and depart for home. The surrounding rocks underfoot are composed of debris flow deposits containing angular chunks of granite unlike any seen in the Grand Canyon to the east. These deposits were clearly shed off a high granitic mountain somewhere immediately to the west. But, where this high mountain should stand before me, the landscape instead falls away with a view over the upper reaches of Lake Mead that fill the former course of the river (Fig. 23.5).

Fig. 23.5. View northwest from vista point on western edge of Grapevine Mesa near the small settlement of Meadview, Arizona. Lake Meade is visible where it has backed up into the former right to left course of the Colorado River. Gold Butte is the pointed peak on the skyline. It is part of a tectonic block that extends to the lower country in the left side foreground.

The river formerly cut and wound its way through this jumbled landscape of mountain range after mountain range. Looking east, the layered rocks of the Grand Wash Cliffs higher up look like the Grand Canyon with only one side present. That is exactly what it is-- the western boundary of the Colorado Plateau holding that great stack of Paleozoic strata I have just traversed down through. After the confines of the Grand Canyon, this expansive view from on high is exhilarating.

The granite boulders in the debris flow deposits here display large feldspar crystals subtly rimmed with another variety of feldspar. I know from geological reports and previous visits to the area that this kind of unusual granite makes up Gold Butte to the north and its extension at lower elevations immediately to the west of this cliff. Could the southern part of that mountain block have once stood high here to the west shedding this debris? Did it cleave off and rotate downward and move to the west away from here like that tilted block I just saw from the north end of this mesa? Was a high mountain once standing up in this huge sky right here where all currently drops away? That would be incredible, so certainly not. Well, actually…. almost certainly yes. Welcome to the tectonic mayhem of the Basin and Range!

It is always difficult to re-enter the real world after a raft trip. It seems as if THAT was the real world. The immediate impact is always the river in all its aspects from tranquil beauty to raging terror as well as the incomparable scenery. Paying attention to the geology and its implications can amplify the experience to unimaginable levels. On the long drive back to Phoenix, the grand themes, insights, surprises, puzzles, implications, and their personal impact rampage in my supercharged mind. I recognize that everything now reshaping my inner life may look different after reaching the summits of the Sierra Nevada Mountains-- so I try to resist drawing too many conclusions at this stage of the journey. The analogy keeps coming back again and again of someone studying human anatomy for the first time and is grappling with what the function and significance of veins in the wrist are without knowing about the heart and the whole circulation system. I am now satisfied that science is not a network of little strands that can be studied in isolation and stitched together incrementally. Individual components must be melded, molded, and continually reexamined as parts of an interconnected whole--the total is more than the sum of the parts. It is the same regarding the emotional reactions which I have not yet fully processed.

The dominant surface feature of solid objects in the solar system is impact craters. This is not the case for Earth which is blanketed with water and layer upon layer of sedimentary rocks as exposed in the Grand Canyon. How such layers came to be is the grand theme of rocks being tectonically uplifted, weathered, and redistributed as sediment. The deposited materials harden into rocks and get deeply buried where they are metamorphosed before eventually returning to the surface again via uplift or melting. The tectonic part of the cycle is apparently powered by heat released from radioactive elements while the erosional sculpting of the surface is powered by the sun. The layers in the Grand Canyon are thus part of a cycle. They are, however, only a patchy record of events for specific time intervals of Earth history. The arrow of time runs through them, but it is not a vertical arrow piercing upward through the

stack because they were not laid down as regional sheets. Stand on a slab of Tapeats sandstone and you imagine a beach environment with energetic currents and waves crashing. But just a few hundred yards to the west at that time, the environment was offshore in deeper and more tranquil water. The muds that became the Bright Angel Shale were being deposited. Farther offshore in the clearer waters to the west, reefs and islands of millions of seashells were piling up into shoals and small islands with more crashing waves. That is now the Muav Limestone. Thus beach, offshore muds, and farther offshore carbonates co-existed at the same time. They were deposited in bands parallel to an ancient coastline. They were continuously accreted laterally into layers as that coastline moved to the east over the subsiding edge of the continent. It is analogous to three dump trucks going down a road with the first leaking sand, the second mud, and the third carbonate. Three layers are thus built up. Time thus cuts across the layers one over the other in an unusual and variable way depending upon the ever-changing geography of the transgressing coastline. The entire stack of sediments is a record of the sea coming in and the sea going out during 250 million years of overall subsidence. The common temptation to think that the whole horizon-to-horizon area of the Grand Canyon changed from sand deposition to mud deposition to carbonate deposition must be resisted. Even the giant wind-driven sand dunes of the Coconino Sandstone may have been originally deposited as broad strips inland of a coastline rather than in a vast desert "sand sea" like the Sahara.

Being immersed in the Grand Canyon and watching all those layered exposures in the cliffs go past day after day brings memories of all the road cuts and outcrops in hills, valleys, and mountain passes that I explored as a student, researcher, and teacher. From little snippets and windows in these limited exposures, I struggled to visualize the subsurface extending for miles and miles in all directions. Like others, I always felt that the geologic record was severely incomplete because we could only sample it in small gulps here and there. However, the record here is exposed in millions of cliffs, side canyon walls, and pinnacles protruding with a freshness rarely seen in rocks that weather out of the ground. It seems like an infinite amount of material to study. It is. There is so much and so much inaccessible that we have only extracted a tiny understanding of all that is there. And yet--this massive volume, this vast exposure, this immense offering of strata and the basement rocks they lie on--represent less than a third of the time that geological processes have been acting on the Earth. Other regions all around the globe hold comparable stacks of strata and what is beneath them. They are from other specific times of Earth history but have not had a Grand Canyon carved into them. They remain out of sight deep in the subsurface. From the days of Charles Darwin, investigators have complained about the incompleteness of the geologic record. No! It is scattered, voluminous, and hardly explored yet. The incompleteness has been our inability to examine it! How presumptuous of us to think we understand so much about the actual history of our planet and the life on it! Even much of what we accept is unconfirmed, controversial, and undergoing constant revision. The record of so long time may be incomplete in its entirety but trying to interpret just that which we can investigate takes the human mind to its limits of

comprehension. I feel exhausted thinking about all that happened in the past, how transient everything is in the passage of geologic time, and how outmatched the human mind is when it tries to fathom the actual history of reality.

The geologic story cannot be appreciated by examination of specific localities alone and without regard to the fossil record of life. For example, aspects of the whole globe are required to interpret the sandstone/shale layers of the Supai as responses to glaciations at the south Pole. Another is how the missing Ordovician and Silurian strata can be attributed to local uplift only after the geology of the surrounding regions is considered. Indeed, interpreting the ages themselves requires knowledge of how the observed fossils correlate with those of the global palaeontologic record. The composition and nature of the strata have been strongly determined by what was living when and where. No life, no limestone. Life on land is paramount in generating soil. No life on land means little soil to wash into the sea to become shale. Biologic enhancement of weathering of all rock types frees the quartz that makes up sandstones at an increased rate. No life, and the sandstones would be fundamentally different. Regional and global climate is also a major factor in determining what type and how much sediment is moved from land to the seas. The layers are therefore immensely complicated regarding from whence they came, what they are made of, and why they formed where they did. Above all, multiple hypotheses ranked according to the strength of the evidence rather than single story pronouncements seem necessary for local, regional, and global interpretations. Geology involves both processes and events. Conceptual and quantitative models are useful for understanding the natural processes at work on and in the Earth, but events and their history require this multiple hypothesis approach. Knowledge regarding the history of these rocks in the sense philosophers and most others use the term must remain elusive. We just weren't there to observe and describe all that happened. Knowledge in historical geology consists of possible explanations. Many fire the imagination, and some are so strongly supported by evidence that they become working hypotheses that do not require further investigation unless surprising new observations warrant reconsideration. Studies so far have barely scratched the surface.

I discovered to my surprise on this trip that there are dark and disturbing aspects of the history of life as displayed in the geologic record. That was my encounter with the dark side of the Cambrian during a reverie involving life in the early Cambrian Sea. The suffering experienced by every creature as an animal necessarily seizes and eats fellow animals along the evolutionary route to consciousness is horrifying to me. I recoil at the idea that this is the way the universe evolved on this planet to became conscious of itself. There must be another way elsewhere in the universe. There must be! Furthermore, this aqueous environment on a tectonically active planet in which all this happened is apparently rare and possibly unique in the cosmos so far as we know. The likelihood of another Earth with a similar past evolution as wildly publicized by enthusiastic NASA astrobiologists is clearly based on wishful thinking rather than evidence.

A raft trip can make you feel insignificant in time and space amidst a cosmic drama being played out on an inconceivably long-time scale that involves inconceivably large amounts of energy. Or, as suggested by novelist Vladimir Nabokov, "…a brief crack of light between two eternities of darkness." This is not comforting to us individuals who are so important to ourselves. I do find consolation because of the profound impact life had in creating the natural history exposed in the Grand Canyon. This impact is ongoing and we, along with past and future generations, are thus of some significance in the cosmic drama after all. Maybe it is only for a speck in a vast universe, but our role as living things is effectual. It is analogous to the significance of an individual voter in a national election. The countless trillions of organisms that altered the chemistry and nature of the Earth's surface did so without the molecular electronic systems we carry around in our recently evolved brains. The evolving neural networks in those organisms did eventually yield an organism conscious of itself and the universe with an ability to communicate, persevere, and ponder like never before. Watching strata of the Grand Wash Cliffs retreat in my rear-view mirror, I feel like I am looking at litter thrown off a pioneer's wagon train traveling toward an unknown region.

For me, this trip through the Grand Canyon was not a thing unto itself. It was part of a larger, aspirational journey involving what this perplexing record of reality partially clarified by geological science might imply. The fabric of the continent just traversed, the rock layers, and the basement rocks extend westward in the direction of my route. However, all those features are about to become disrupted, modified, supplemented, shredded, and filled with history majestically displayed but difficult to comprehend. The exposed reality in Grand Canyon provides an essential reference and goodly frame to carry into the products of this tectonic mix-master. This end to the raft trip is a beginning.

Philosophers have been arguing for thousands of years about whether there are two distinct realms –immaterial minds that think as opposed to the material things mechanistically governed by universal laws of physics and the conservation of energy. There is a real question about whether thought, behavior, and indeed all aspects of the mind are ultimately just the result of life evolving according to "survival of the fittest." Are love, empathy, music, art, poetry, curiosity, cruelty, hate, awareness, creativity, and such things we attribute to mind really just neurological ramblings that evolved only because they make the search for prey more successful and survival more likely? Why, Darwin even suggested that music, no matter how profound, is not mental creativity but instead merely sublimated mating calls. Is the entire universe, including our inner lives altogether mechanistic? Is everything just following immutable laws and strictly determined by the way energy cascades from higher to lower states as modeled by science? Is the search for meaning and significance in natural history merely a manifestation of mind trying to enhance survival strategies? Is my pilgrimage a silly waste of time? I could become convinced of all this were it not for a certain reading assignment in a course I took as an undergraduate at the University of Chicago called "Philosophical Aspects of Biology." Here is an excerpt from the 1953 article by Sewell Smith in

the journal “American Naturalist” that has haunted me unmercifully ever since—even while pondering the geology on this pilgrimage:

> “It is a rather remarkable phenomenon from the purely physical standpoint when many tons of metal rise from the ground in Newfoundland, move through the air over the Atlantic Ocean and finally settle down gently at Shannon Field in Ireland. Yet an engineer studying the air pressure in the wings and ailerons of the plane in question, the movements of the ailerons and their relation to certain lever movements, the motion of the propellers, the mechanical relations to the motor and-the gas explosions in the latter would find that the plane was merely following a necessary course, determined at all moments by well-established physical principles, except that he would not understand on this basis the succession of movements of the lever. This, however, would involve only an infinitesimal portion of the total energy transactions. A physiologist, taking up the interpretation here, would find that the levers moved as they did because of a certain succession of muscle contractions (of the pilot) and that these were in full accord with the principle of conservation of energy. He might trace the energy transformations in great detail around the adenosin triphosphate cycle, the creatine cycle, the phosphorylation and dephosphorylation of glucose in its breakdown to pyruvic acid, the 4-carbon cycle, etc. All energy transactions might be accounted for except perhaps infinitesimal portions of the total, involved in determining which muscles contracted. Another physiologist might then take over and trace what happened in the neuromuscular junctions and in the nerves. The energy transactions here are only an infinitesimal portion of an infinitesimal but he would find that the conservation law still applied except perhaps for infinitesimals of the third order in events at synapses in the nervous system. The flight of the plane would all be accounted for mechanistically except for something like an infinite regress of infinitesimals. Yet the whole was according to plan.”

Maybe there is an immaterial soul after all. Maybe my pilgrimage marshalling reality versus assertion is indeed on the right path. Maybe the music that sends me soaring through other worlds is not just sublimated mating calls. Whose poetry is that I suddenly hear resounding? Why, of course--Walt Whitman.

> *Away O Soul! Hoist instantly the anchor!*
> *Cut the hawsers—haul out—shake out every sail!*
> *Reckless O Soul, exploring, I with thee, and thou with me,*
> *Sail forth, steer for the deep waters only,*
> *O farther, farther, farther sail!*

This journey will continue.