

The last camp at the helipad is different. Upon landing, our group is directed to surrender life jackets to a pile off the bow, remove drinks and anything personal off the boat, and “begin camping.” The campsite is small, and people quickly scatter and snatch up any spots that offer a bit of privacy. About half just walk to the periphery of the sand beach and start a tent city in case of rain. The crew immediately goes to work rigging the boats for a fiendish run they must do the next day. Helicopters will lift the passengers out early next morning, and the boats will rocket out the remaining 90 miles to an awaiting semi-trailer truck that will drive them back to the Hatch warehouse. It will be a grueling day for the crew, and I will be going with them to push my pilgrimage westward. Without a break, they start deflating the side pontoons and mounting a second engine on the back of each boat to allow maximum speed for the long ride tomorrow.

We have arrived at a place where the river eroded down one side of the lava layers in the channel to leave this tall cliff of strata facing a cross section of the flows still lodged against the far wall. River sand is currently piled up against the base of the cliff into a 20’ high hill that slopes on the downriver side to a small beach just big enough to accommodate commercial raft trips. Heavy rains and runoff over the cliff have eroded the upriver side of the sand pile into a gully. The top of the hill is gently rounded but has been flattened to form a helicopter landing area just a little bigger than what is needed to make room for the skids. No helipad could be smaller or more tightly ensconced between the river on one side and a vertical cliff on the other. A helicopter cannot safely land or take off from here in gusting wind. This is the only operational helipad that commercial raft trips can utilize in the Grand Canyon (Fig.21.1).



Fig. 22.1. Helipad and last campsite. Remnants of lavas that flowed down the channel remain on the other side of the river from this cliff exposure of Cambrian strata. The camp area is on this river sand that drapes up and over rubble collapsed off the cliff face.

It has always been my practice upon arriving at a campsite to schlep my camping gear far away to not hog the best tent sites near the kitchen--and so that I can be alone if possible. This involves going far back from the river or far down the beach. Neither is an option here. The only walk in one direction is to a porta potty spot and the other is blocked by the big sand hill and its far-side gully. There are several nearly level places for tents along the 50 yard walk up to the helipad, but you will have close neighbors. It is impossible to get a secluded campsite. Or is it? Years before, I discovered a private spot on a ledge above the helipad. Below it is a large pile of talus largely covered with sand and brush. A protrusion of the bedrock extends out from the east end of the ledge. Sand sloping up to that protuberance is what was leveled off to form the helipad. The obscure path up to the ledge goes through growths of thorny desert plants that largely conceal it (Fig 22.2).



Fig. 22.2. Vibrating view from departing helicopter of a group waiting to be lifted out. The helipad is uphill to the left of the people and just off the left edge of the photo. My secluded campsite is against the wall and behind the bushes near the center of the left edge. The route to it turns off the sandy path nearest the wall and then through the thorny bushes. Everyone is turned and cowering from the hurricane blast of takeoff winds. (Photo by Laura Knauth).

The flat area is just big enough for a cot but not a tent. It has a great view across the river. This hidden spot is almost always vacant because the climb up that steep sandy slope to get there is two steps forward, slide back one, and then crash your way through a briar patch. Each year the climb taxes me more and more, but I love sleeping there alone. I am always emotionally exhausted at the end of one of these outreach trips and find comfort in solitude. Alarm! This year I find a compressed pile of shale and broken sandstone that fell off the vertical cliff right next to where I usually set up my cot. It would have just missed me. This cliff face of thin sandstone layers interbedded with shales is actively falling apart. It is something I always worry about when sleeping here--especially since once upon a windy night, little flakes of shale kept falling around and even directly on me. I always comfort myself with the knowledge that cliff failures usually occur during heavy rains. My little ledge will soon be either entirely buried by falling piles or degraded further by slope erosion-- but there is still room enough for tonight. There are some clouds, but they do not seem to be rain clouds.

After two exhausting trips from the boat to get my gear up here to my eagle's nest, I sit on the cot to ponder the amazing scene across the river and all that we have seen on this trip.

I worry for a second that the clouds might be building, but the sun pops out until shade from the far side of the river envelopes our camp area. A cross section of lava that once flowed down the river lies breached along the far riverbank. Those lava flows clearly once filled the channel all the way over to this wall where I sit, but they were subsequently removed as the flowing river gnawed into the softer sandstones and shales that make up this wall behind me. I get lost in thought wondering why volcanos erupted here and shed lavas into the river. There is something special about the Colorado Plateau here.

Flagstaff sits on another eruptive center about 100 miles to the southeast, the so-called San Francisco Volcanic Field. So much lava came up there that it melted much of the lower "granitic" crust. Sticky explosive lavas of this melted and recycled granitic crust blew out to form the highest mountain in Arizona (12,643') about 3 million years ago. Lavas from the mantle made it up to the surface there as well, the latest having erupted just northeast of Flagstaff 900 years ago. Another major field in Arizona 200 miles to the southeast near Springerville has eruptives as young as 300,000 years. There is thus a band of volcanic centers running NW to SE across Arizona. Springerville also sits near the southwest end of a row of five one million-year-old volcanic centers called the "Jemez Lineament." It runs northeast to southwest at right angles to this line (Fig. 22.3).

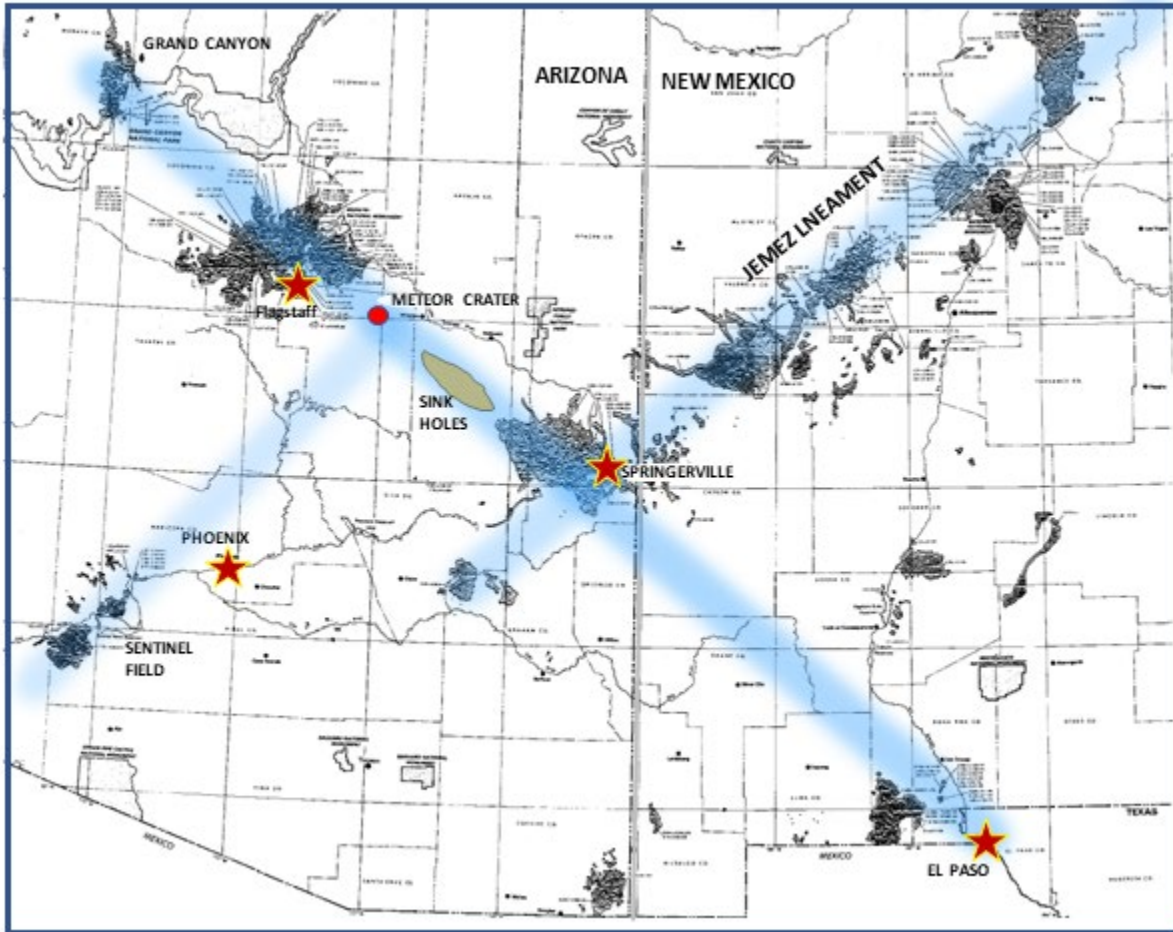


Fig. 22.3. Bands real or imagined that run through the less than 3 million year old volcanic fields in Arizona, New Mexico, and Colorado. The broad bands are centered on eruptions less than one million years old. The NW to SE "lineament" extends from the Lava Falls area through Rattlesnake Crater in the volcanic field near Flagstaff, across Meteor Crater, an elongated concentration of sinkholes, the White Mountain field in Eastern Arizona, and eight explosive blowouts less than 500,00 years near El Paso. The famous NE to SW "Jemez Lineament" intersects this alignment near Springerville, Arizona in the White Mountain Field. Meteor Crater lies on a line roughly parallel to the Jemez Lineament that passes through the young Sentinel volcanic field. "Lineament geology" is suggestive but rarely has any physical significance. (Modified from Los Alamos National Laboratory Publication LA-881 2-MAP)

Many have speculated that the Jemez Lineament indicates a "mega crack" in the Earth's crust that triggered or allowed deeper magmas to preferentially rise to the surface. So, could the lineament running NW to SE across Arizona be another mega crack in the crust? Remarkably, these two lineaments at right angles to each other are aligned parallel to the perpendicular fracture directions that account for the block-like scenery in the Grand Canyon. Are there zones of regional tension deeper down in this part of the Colorado Plateau that trigger melting and explosive volcanic activity? It is tantalizing to note that an extension of this NW-SE line across Arizona appears to extend all the way to some odd, one million-year-old basaltic eruptives near El Paso, Texas. Is there deeper significance regarding the locations of these

youngest volcanic fields—including the one I am sitting on right now? Probably not, because speculation often grades into fantasy and nonsense. I regularly entertain such thoughts that so easily irritate my professional colleagues. Straight lines can be drawn across gaps in text on a book page. But wait!

During an airliner descent to Phoenix from the northeast, I was once struck by the sight of a cluster of sinkholes southeast of Meteor Crater seemingly on a straight line that ran directly across that famous crater and over an explosive, one million-year-old volcanic explosion crater in the San Francisco Volcanic Field near Flagstaff. Here were sinkholes on a straight line with an asteroidal impact site and a volcanic explosion. Surely none of these have anything to do with the other; it must be a chance alignment created by the mind where there is none in physical reality. Then I remembered that these sinkholes known as the “McCauley Sinks” are a cluster along a line extending to the southeast for at least 35 miles to near the town of Snowflake, Arizona. This “coincidence” needed at least a cursory examination because I hate dramatic coincidences in science. So, getting back to the office the next morning, I pull out some geologic and topographic maps of Arizona and put a long straight edge over the McCauley Sinks, Meteor Crater, and Rattlesnake Crater. My jaw drops when I realize that Meteor Crater and the row of sinkholes are right on the array of million-year-old eruptive centers that define the possible lineament running across Arizona. That alignment I saw out the airplane window extends all the way to the volcanic eruptions that sent lavas over the walls of the Grand Canyon about a million years ago. Extrapolating far to the southeast, the lineament goes to some million-year-old explosive vents near El Paso. An array of sinkholes and an asteroidal impact site lies right on the big lineament of volcanic fields that stretch across Arizona from northwest to southeast? Is it a perfect line? No, but it is a narrow band less than about 10 miles wide—even narrower than the Jemez Lineament. What? Why should an impact crater about 20,000 years old, four volcanic centers of roughly the same million-year-old age, and prominent modern sink holes all fall on a line? There is no physical connection between the features. They formed in different ways. Although all probably formed in the last million years, the ages are probably not exactly simultaneous—especially the regard to time of the meteor impact (50,000 years ago). Finally, there are sink holes in many places on the Colorado Plateau, albeit not an array of young ones like this. This lineament may be “a false creation of the heat-oppressed brain.” It must be, so I decide to forget it and get back to work.

As I walk back to my desk, I suddenly recall the Sentinel-Arlington Volcanic Field in southwestern Arizona. Back to the drawing board! This field consists of two clumps of one million-year-old cones and eruptive centers with one lying northeast of the other. Put a straight edge parallel to the NE-SW direction of the Jemez Lineament through them, and it passes close to or even through... Meteor Crater (Fig 22.3)! A line passing through the northeast and southwest corners of this almost square crater points right at those two clumps of young volcanic cinder cones. The other great “lineament” running NW-SE through the Arizona volcanic fields goes through the northwest and southeast corners of it. Meteor

Crater is probably the only known square or rectangular crater in the solar system. The conventional explanation is that the impact produced an explosion that peeled sedimentary layers up and over along the regional joint pattern like petals on a flower. But—impacts that occurred elsewhere on Earth on sedimentary layers apparently did not peel them back like petals on a flower. Those craters are also on uplifted terranes with regional patterns, but they are round like impact craters on the Moon or Mars. I really became tormented. This cannot be. The alignments are not exact and great circles fitted over this distance would curve a bit. All this could be...must be...just a coincidence. Why, I bet I could find churches and bars close to one of the putative alignments going through Meteor Crater. But...why would an asteroid slam into the Earth right on a volcanic lineament and maybe even at the intersection of the two of them? Why would sinkholes form subsequently along one of them?

Kind of shell-shocked, I hear the footsteps of the elderly Robert Dietz coming down the hall so empty at this early hour. Dietz was a free thinker unafraid of academic elites and one of the founders and pioneer advocates of the theory of Plate Tectonics. He was also probably the first geologist to claim (in 1948) that Arizona's meteor crater, long interpreted as a volcanic explosion, was instead an impact structure and that there were hundreds of other impact craters globally. These ideas were initially ridiculed by the elites of geology. In fact, while an undergraduate student at the University of Chicago, I attended a seminar given by Dietz on his "astroblemes." During the question period afterwards, I remember a famous geophysicist rudely say in response to one of Dietz's answers, "That's the first reasonable thing you've said all day." I would never have believed then that I might someday be Dietz's official boss at a university or that a lot of the skeptical elite would later run to the front of the parade. He came to Arizona State University late in his life, arriving shortly before I did in 1979. So, here he is dragging his stroke-ridden body down the empty hall early to work. This was an almost daily ritual in which he would stop at my open door, thump his cane, and say with a smile on his face, "Clean up this office!" I would always respond, "I just did." He would then laugh and shuffle away to his own office. This morning, I invited him in to look at the big map with my meter stick laying on it.

If the big lineaments were crustal cracks I tell him, then I might interpret Meteor Crater as a blow-out from the mantle like known examples not too far away northeast of this square hole. An explosion certainly was here as would have happened in an impact. But maybe it was a really big volcanic blow out as was explained for its origin for over 50 years before Dietz began arguing it was an impact crater. I show the conundrum to Dietz, and he says with wisdom and a big smile, "Lineament geology is the lowest form of science." I reply, "Yeah, and besides, we KNOW that Meteor Crater is an extraterrestrial impact because there are millions of iron-nickel meteorite fragments lying right there near it." Dietz stares thoughtfully and says, "Come with me."

We walk down to his office, and he pulls a huge volume off his shelf--a compilation and brief description of all known meteorite craters on Earth. He looks up "Gros Bruggkaros," and it indicates that this circular structure in South Africa is symmetrically surrounded by a strew

field of iron-nickel meteorites. However, intensive geologic studies show that the site is not an impact crater but instead is a diatreme that has been actively blowing out for almost 500 million years. The strewn field of iron-nickel meteorites is a coincidence. "I was convinced that the coincidence of iron nickel meteorites with a circular feature was unlikely, so I went there to see for myself if it might actually be an impact crater," said the old man. Then he said, "Yep, the presence of iron-nickel meteorites doesn't matter--it is clearly a diatreme." I looked at him speechless. With a wry smile and twinkle in his eye, this champion of terrestrial impact craters says, "Keep thinking." I left like the wedding guest in Coleridge's "Rime of the Ancient Mariner...."stunn'ed and...of sense forlorn."

Sitting on my cot across from the black layers of lavas lining the far side of the river, all this rampages in my head still rattled from running Lava Falls not long before. I continue to ponder these completely heterodox ideas but have never found a receptive listener since Bob Dietz. If there is one thing we know in all geology, it is that Meteor Crater IS a meteor crater. Why, shocked quartz and fragments of an iron meteorite are all around. Tell anyone nowadays that you are even open to reconsidering that it might be an extraordinarily powerful explosion from below, and you will be branded as a Flat-Earther and a pestilent fellow. But the Earth does appear to have an iron-nickel core. Could part of that somehow have gotten churned up into the mantle and come up in a deep-seated, gas-driven explosion to produce the iron-nickel chunks around Meteor Crater--and Gros Brukkaros? Is there an intersection here of two great cracks (or zones of enhanced tension) in the crust that allowed a powerful gas eruption/explosion to create a crater and focus shockwaves along the fractures that allowed sinkholes to form subsequently? While I think about this from time to time, I have tried to set it all aside as a hopeless pursuit if I want to be taken seriously regarding other things. Being free nowadays of the necessity of getting positive reviews on grant proposals in order to maintain my "tenured" job (a constraint steadily leading to the destruction of innovative science), this is now a matter to me of supreme indifference. So here I sit looking at the black lava on the far side down by the river and wonder again if this black lava may be part of a much larger story. Scientists sometimes fall into paradigm locks such that free thinking is discouraged for those that want to have a professional career. How many other scientific situations are there like this? I am left with the logical and still peer-pressured conclusion that all these alignments and pseudo alignments are a coincidence and that Meteor Crater is best interpreted as an impact structure. Indeed, I guess I would bet on it. Improbable things do happen, but I find no logic or comfort in the explanation offered by a dismissive colleague that it is just as likely that an asteroid would hit the Earth there as anywhere else. At the intersection of these lineaments if they really exist? This is how you use statistics in science? Madness. A loud yell from the kitchen area for hors d'oeuvres breaks my troubled trance. No more these thoughts, no more. But I still see and hear Bob Dietz with that inviting smile and twinkle in his eye saying, "Keep thinking." That is an existential condition I remain unable to shake.

Everyone has gathered into a chair circle jabbering and waiting for dinner. I open a microphone and ask if anyone would like to comment about what struck them the most on the trip. Most talk and each has a different read; all seemed to have been deeply moved by the experience. Darkness falls, we eat, and JP explains to us what will happen in the morning and what we must do before the helicopters start arriving at 7 am. Because of much vino and other distillments, the logistics are only partially absorbed. It does not matter because we always work it out in the morning. Instructions in the evening on a raft trip just don't work.

My self-assumed responsibilities for this charter raft trip now ended, I leave the group still celebrating and slog up on the sandy route through the bramble bushes to my hidden refuge at the foot of that crumbly wall. I am soon flat on my cot slowly committing myself to sleep and relieved that spaces between the broken, strung-out lengths of puffy clouds are increasing. Clouds far from city lights are darkly silhouetted against a brighter sky, but these are beautiful white indicating the moon is up somewhere above the cliffs. These lovely clouds now slowly disappearing reassure me that there will be no weather troubles to interfere with the helicopter exit now less than nine hours away. Nor do they challenge my usual decision not to set up a tent—especially here where there is no room.

Peaceful sleep becomes troubled when I dream that scattered raindrops are splatting on my face. Wait! This is no dream. I blink awake. The white puffy clouds are gone; the sky is completely dark. And-- raindrops are indeed falling. They stop, and then start again, and stop. I decide that something lingering above is passing and that this is probably but a momentary concern. Nuisance that it is, I conclude I should drag all my loose bags and gear under the cot, pull out the rainfly from my tent bag, and just drape it over me and the cot. I try to resume a peaceful sleep. The rain drizzles a bit, slows down, and increases again. After several cycles, I doze off until I realize that the rain is now coming down steadily. I start worrying about this wall next to me. Big parts of it might come down if it gets thoroughly wet. Just ten feet away from my feet sits that huge pile that fell right where I slept last year! Does this mean that the wall around it is now more susceptible to failure? Surely, that rockfall happened in a much heavier rain than this. The rain then lets up a bit, and I fall off again into a fretful sleep. A loud thud awakens me. A rock has fallen not far from the head end of my cot. Or was it a troubled dream? Being nervous, I cannot decide. For sure, the rain is steady now. I become alarmed, put on a headband flashlight, and slide my head under the rainfly out over the edge of the cot to see if water is flowing under me. It is not, so this is a good sign. The rain continues to intensify. Thunder rumbles. What are the chances crumbly walls like the one I am now foolishly sleeping next to shed material or collapse in these conditions? Lots of rain has hit this wall over and over in past years, and it is still intact. I tell myself to relax because the odds are almost certainly in my favor. Now the wind starts fluttering the rainfly. I start stuffing the ends into where the blue nylon net fabric of the cot goes around the aluminum support legs. Lightning and the sound of rain pelting the ground, the wall, and the rainfly become fearsome. The sheltering rainfly is now drenched and feels wet when it touches bare skin. I look again, and water is now indeed moving under the cot. Lots of it. Water is clearly streaming down the

cliff face now. The situation now seems perilous, but what can I do? I could leave to get away from this wall but where to go? What about all my stuff I didn't pull under the cot? Now, the lightning is followed seconds later by loud thunder and heavier rain. The storm is still building. I begin to panic for the first time in my life. This wall is going to fall and kill me. In the grips of paralyzing terror, I bemoan the fact that the last thing in this life I will see in the white light of my headlamp under this now almost useless rainfly is the sight of blue nylon mesh stretched tightly around an aluminum tube. Must this really happen? NO! This is unacceptable, not just that I might die, but that I am just laying here emotionally terrorized. There is no chance I will go to sleep here again tonight. None! It is time for decisive action. I must get away from this wall as fast as possible no matter the odds that it will fall or not.

Reaching under the cot, I yank my raincoat and pants out from the daypack. Then-- wiggle, twist, and squirm into them while staying under the drenched rainfly that hangs, flaps, flops, and sticks to everything. I frantically pull out a small, rolled-up air mattress from another bag, slip my feet into flip flops, grab my little air pillow, and rapidly skedaddle slipping and sliding down the slope away from the wall. I have never moved this carelessly in the dark anywhere in the Grand Canyon. The claws and thorns on bushes lining my descent tear at my rain suit, but I just want to get away from that soggy wall ready to break away. Going down the steep, slushy, sandy slope in flip-flops and rain is a new experience. I don't care because I am no longer near the base of that vertical wall. Let it fall! Ha-ha...but wait...no relief yet. Where shall I go for shelter in this deluge which may get even worse? A bright lightning flash with accompanying boom illuminates the whole area. I see tents scattered ahead of me in level clearings on both sides of the way toward the boats. How I envy the people all dry and snuggled unafraid in those sturdy shelters. Here I walk past them—a shell-shocked orphan without a destination in rain, lightning, and thunder that reverberates off walls and cliffs. The rain lets up a bit and then—an idea!

The crew set up heavy aluminum tables in the kitchen area as they do at every camp. To keep the beaches clean, they put carpets under and around each to collect any tiny food scraps. Two tables are usually set together and covered with clip-on, plastic-coated tablecloths. To me, this seems like a roofed shelter where a lost pilgrim might find refuge. The kitchen area is a welcoming castle when I arrive. I crawl under a pair of tables holding the heavy dish washing buckets. Rain falling on the uphill sand simply sinks rather than flowing over the carpet. Other than drops blowing in from the side and splashing water running off the downhill edge of the table, this is a dry enough refuge. I only partially blow up my little air mattress because not much of a cushion is needed on this carpet covered beach sand. I stretch out arched a bit downhill in a fetal position to avoid drips coming out from the junction of two tables. SAVED! The raindrops hit the tabletops like a machine gun and get amplified by impact on the metal. I have taken refuge under an orchestra of dissonant gongs. Lighting flashes, and thunder rumbles. So what-- “You cataracts and hurricanoes...spout rain...crack your cheeks...rumble thy bellyfull...etc.” I am safe curled up here in my rainsuit and shielded from the enraged battles in the sky. My watch says 1:45 a.m. I can still get several hours of cozy

sleep tonight. Adrenalin from a panic can apparently subside as fast as it arrives because I am sound asleep in no time.

My eyes open to see faint morning twilight above the high eastern horizon. It is 4:30 am, no wind, and clear skies! I slept hard. Doubt I even moved because certain bones are aching. Everyone seems to still be asleep. I crawl out into the beautiful world again, and head back up the hill. Behold! There is no pile of rocks covering my cot. Nothing fell. There is no fallen rock in a crater near the head end of my cot. None of my scattered, wet stuff has blown or washed away. The whole scene is dripping wet but otherwise normal. The terror and first panic attack of my life appear to have been unwarranted. Ah, well, I think. Better safe than sorry. But wait! That wall is soggy and could still fall. Here we go again. I pack fast. Before the call for morning coffee, I have put myself and all my paraphernalia back together and already lugged one load down to near the front of the boats. I will need to pile all onto one of the boats because I will depart with the crew after the helicopter exit of the passengers is complete. Following such a horrible night, I am surprised how energetic I feel. I think it is joy and relief that I am alive.

The helicopter exit is tightly choreographed and results in the group waiting around to be called up to the helipad in groups of six as two helicopters alternate the 25-minute round trip to R Bar Ten Ranch several miles to the north. A group like this usually develops strong interpersonal bonds and there are many teary-eyed farewells as group after group lifts off. Of course, everyone will immediately run into each other again at the Ranch where they wait in a nice facility until fixed wing aircraft land and take them back to the Hatch Warehouse or to the Las Vegas airport. Before the last group departs from the helipad, boats from other companies arrive from upriver campsites to unload passengers and sometimes take on new ones flown in from the ranch for a two-day trip down to Lake Mead in the vacated boats. A legendary river character named Garth Bundy arrives with the first chopper and runs the show. He sits on a huge block of rock and entertains those waiting with jokes and stories. I sit with him and try once again to give him some new jokes. It has never worked before, so I do not bother to tell him this time about an idiot that once camped in a rainstorm at the base of that crumbly wall overlooking the helipad.

For years I would put a portrait lens on a big camera and get face shots of individuals and couples as we waited for the helicopters to remove us one group at a time. Here were weather-beaten people with frizzled hair, men unshaven, women without makeup, and all caught happy, relaxed, and off guard. Unpredictably, these are wonderful portraits because the raft trip experience apparently infuses a glow on the face that is easily captured. I love and treasure these images and have often wondered how they would fare in an art exhibition. They are portraits that tell a story. Alas, I am not an artist.

JP and I hang around until the last person from our group is seat-belted in the helicopter whereupon we move with alacrity down to his boat. Our other boat with the other two crew members is already long gone. A tough day of driving 92 miles at maximum speed to get to Lake Mead is ahead. A big Hatch flatbed semi-tractor trailer will be there to collect the boats and return them and the crew to the warehouse. The hectic runout is not a scenic tour, but I

want to experience this part of the river again as part of my pilgrimage. We put on sound-suppression earmuffs to protect from the full-throttle noise of two motors and hang on as we rocket away. With the side pontoons removed and stored, this huge raft zips along like a speedboat. It is a new sensation to motor at warp speed through the Grand Canyon. The last helicopter flies past and we exchange waves with a couple of our people at the windows.

The scenery changes immediately. The canyon walls move back in great steps with the highest parts now a distant skyline. A broad open area appears and then we are back between narrower canyon walls, but not so high and narrow as before. We have crossed the Hurricane Fault west of which are tectonic blocks that moved up and down. The river continues to cut downward so that we are soon travelling through the granite basement again. But all is different to my eyes. The rocks are deeply weathered down the joints leaving few sharply defined cubes and prominent blocks. Fracture intersections are more rounded than any stretch previously. The angular masses of granites and schists themselves seem to have had a different tectonic experience which involved more brittle shattering than seen back in the Inner Gorge (Fig 22.4).



Fig. 22.4. Brittle deformation appears to dominate in this jumbled aggregation of schist masses downriver from the helipad. The tectonic block west of the Hurricane Fault may have had a significantly different burial and tectonic history from the blocks to the east.

The upper parts of the Paleozoic layers are more removed and stepped farther back than anything heretofore. As we blast along, it seems like another, older Grand Canyon. It is certainly more degraded by erosion. Is all this related to the Hurricane Fault or is it an older River channel that somehow connected with a more recent incision? Or am I just now noticing features that have been developing continuously as we moved downriver? A standard explanation for the origin of the Grand Canyon has the river carving west to east across the Kaibab Uplift, so it would make sense for this stretch to have a longer incision history.

The downcutting history of the Colorado River remains highly controversial. The literature is complicated with some workers claiming the gorge was already cut down to almost its present level over 50 million years ago while others claim the whole business formed in an episode of furious downcutting during the last five million years. Highly technical arguments based on geochemistry made by several Caltech researchers recently argued for the oldest age scenario as earlier proposed by Don Elston. However, Karl Karlstrom and colleagues at the University of New Mexico and elsewhere have contested these results. They started full time investigations about 20 years ago determined to settle this question and many others. In a stream of publications, they supported the very youngest ages championed by McKee, Lucchitta, and others. Other geologists have been trying to solve the problem by working upriver from the Gulf of California to piece together with considerable success how and when the river connected with the ocean. The mouth is currently at the head of the narrow Gulf of California where the oldest fossils in marine sediments indicate that this long oceanic embayment opened less than 5 million years ago. If the river is older, it must have debouched into the ocean elsewhere or gone inland until the Gulf opened. Areas west of the Grand Canyon are highly disrupted by ongoing tectonic mayhem, so other places where the river might have gone are problematical. Don Elston suggested that the river originally flowed in the opposite direction up into Utah in response to the tilting up of the Colorado Plateau toward the northeast. This uplift started about 50 million years ago and lasted until the Uinta Mountains rose in Utah and the Gulf of California opened to the southwest. He suggested that during long periods of dry climate, river flow may have diminished greatly allowing debris flows and wall collapses to substantially fill the canyon. When wetter times returned, the river began flowing again, but now headed for the Gulf of California. To someone like me who just reads the various papers without a dog in the fight, it is all bewildering. Positions on technical points change and shift from paper to paper, even those written by the same authors. All these explanations sound good after I read them. I am disappointed that some simply dismiss the Caltech data because they conflict with their views. However, this may be one of those large issues where passionate advocates of a certain theory are tempted to focus on observations, data, and publications that support their prejudices. One published exchange involves a direct accusation of such cherry picking. Everyone is making heroic efforts I admire,

but I remain skeptical and without prejudices because things just do not add up. Different philosophies of science may be adding to the confusion. Do you break everything down into bits that you figure out and add together into a web the way philosopher John Stuart Mill and others advocated, or do you need to stand back and deduce the function of the heart before you try to understand the veins in the wrist as per the philosophy of William Harvey? Or is a new philosophy or combination of philosophies necessary to understand geologic history? Geologists usually compile multiple hypotheses that they rank according to probability. The variables, processes, and regions involved are so complex that one person or even a team of cooperating specialists can easily go wrong. Teams often have the fatal problem of members simply trusting and relying on others proficient in specialties that they do not understand. Proof or truth about what happened in the past may be unachievable in the same way that aspects of human history can never be known. If so, how do we deal with that? These are overriding issues my pilgrimage must confront. For now, I am on a rocket blasting down the river in the hot sun trying to keep a big California lifeguard hat from flying away.

It is a struggle to keep up with where we are. I do not want to distract JP with questions or deal with the flapping pages of my river guidebook. This is not the greatest way to connect feelings with the Grand Canyon and ponder what it all means, but the scenery is certainly dramatic, variable, and interesting. Straight ahead, a landmark known as Diamond Peak comes into view (Fig. 22.5).



Fig. 22.5. Diamond Point. A major access route to the river from the south is via a primitive road going along Diamond Creek behind this pyramid-like erosional remnant of Paleozoic strata. Many raft trips end there.

That is at mile 255, so we have 70 miles to go. Immediately behind the peak is Diamond Creek where a road from the south comes down from Peach Springs. The entire area south of the historic high-water mark of the river from mile 165 (across from Tuckup Canyon) to mile 274 (about 4 miles short of the western end of Grand Canyon) is the Hualapai Indian Reservation. The Hualapai operate service vehicles that can carry people, boats, and gear, so many private row trips end here. The National Park Service still controls the river and allows two private groups per day to launch at Diamond Creek. They will travel 2-5 days down to Lake Mead. The mouth is deserted today when we pass it.

We go by another spot unique in both scenery and history 14 miles downriver from Diamond Creek. It is Separation rapid where three of Powell's crew left and disappeared into history (Fig 22.6).



Fig. 22.6. Separation Canyon where three members of the Powell Expedition departed on foot. No record or compelling evidence of what happened to them is known.

I look up the straight, broad canyon to the north, see subdued mountains in the distance, and appreciate why this looked like an opportune spot to escape the canyon prison they were slowly dying in. It is the first such spot inviting an escape that I have seen on the trip. I long to hike this route and relive what the escapees must have been thinking and try to reconstruct

the most logical route they would have taken. Many have already studied all this, so it is a silly daydream. However, driving around the dirt backroads of the public land in this very vacant stretch of the United States north of the Canyon remains appealing. I vow to do it someday. We pass rapidly with no time to reflect, connect, or ponder the investigations and stories regarding what happened to the three tattered chaps. JP resumes reaching over, thumping me on the shoulder, and points. I nearly always see the geological feature he indicates and nod back--often with a thumbs up. We are both wearing ear protection from the double engine noise and cannot engage in our usual banter.

The rapids are now noticeably diminished in size, although there are still a few thumpers big enough to flip a boat like ours stripped of its side pontoons. We get flagged to pull over to a group of three row boats holding four sunburned people looking exhausted, overheated, disheveled and disheartened. There is no beach to land, so they are nudged up against some jagged rocks. They ask JP how much farther it is to Lake Meade and how long does he think it will take them to get there. They will be rowing the rest of this day against a significant wind funneled through the still imposing gorge. JP says they will not make it today and asks if they have provisions left to camp. They indicate they are well stocked but that some ice would be forever appreciated. JP obliges with a big block that clearly lifts their dejected spirits. We speed away feeling a little guilty about how well off we are and how soon we will be at the end.

The water of Lake Mead has backed upriver such that the river current is noticeably diminished from here on. Indeed, motorboats have come upriver all the way from Lake Meade to Separation Rapid. Some very powerful ones even went all the way to Lees Ferry once before the National Park Service began regulating boat traffic on the river. However, the lake level is currently way down because of drought conditions, so this lower stretch becomes increasingly walled by gray muds that once formed the lake bottom that came far up the river channel (Fig. 22.7).



Fig. 22.7. Channel walls of mud and silt layers deposited during the highest stands of Lake Mead after construction of Hoover Dam about 100 miles downstream.

The sediment is young and remains unconsolidated and only weakly cohesive. Disembarking along the banks would now require frustrated climbs or some serious digging. Jagged black sticks, tilted bare trunks, and dead brush that once hosted green vegetation along the banks stick out while the former sediment now slumps into the river. In places, the increasingly strong winds blow dust clouds off the banks and out over the river. Driving into the sun and wind, the canyon walls are now recessed back from the river and shrouded in a featureless haze. Brief glimpses of the former glory appear when we pass side canyons. The walls remain imposing and continuously remind us we are still in the Grand Canyon.

Compared with the views of the past week, some might consider this stretch in mid-afternoon a dismal sight. It isn't at other hours. We pass a little dock with some buildings and a big helipad on the south side. It is a tourist spot run by the Hualapai Indians (Fig. 22.8).



Fig. 22.8. Boat dock for Grand Canyon West, a commercial enterprise of the Hualapai Tribe.

Daily helicopter tours arrive here from Las Vegas or a facility high up on the south rim. Amazed passengers are then given boat rides along this lazy stretch of the river. Two empty tour boats approach us and blast past without the boatmen acknowledging my waves. At one point, I see the famous “Skywalk” glass-bottomed walkway looping out over a side canyon (Fig. 22.9).



Fig. 22.9. The Sky Walk over a side canyon at Grand Canyon West as seen from the Colorado River.

The Vegas tourists are taken there and allowed to walk out and see a side canyon between their feet—if they are brave enough.

This spot brings up wonderful memories of when I used to bring classes to a promontory that does jut out near the river, formerly called “Quartermaster Point.” It was a wonderful view of the westernmost Grand Canyon (Fig 21.10).



Fig. 22.10. View west from promontory formerly known as Quartermaster Point on the Hualapai Indian Reservation. This viewpoint is now part of the Grand Canyon West enterprise. The cliffs here extend downward from the Supai Formation to layers of Lower Cambrian Strata.

The views and geology underfoot there were spectacular. We could examine the paleokarst atop the Redwall, magnificent cherts and sedimentary structures in the Supai, and great exposures of the Devonian Temple Butte Formation. On the drive in from the west it was possible to study the lower Paleozoic rocks, the Supai, and the Redwall Limestone without taking a raft trip or a death march hike down from the South Rim. I think the biggest chert nodule in limestone I ever saw is in a roadcut there through the Redwall Limestone. Alas, access for classes or any visitation is now more complicated and possibly expensive. The Hualapai started with a little casino on the rim, but it flopped. Buses from Las Vegas would be greeted by a Native American dressed up like a Hollywood Indian. That was a bit much, but the

Hualapai understandably want to cash in on the appeal of the Grand Canyon. Aside from tourism and casinos, there are few other economic engines operating on reservations. After all these years, the United States has not successfully dealt with the genocide and brutal occupation of tribal homelands. The Native Americans that survived have somehow maintained their basic identities but have only rarely become economically fulfilled. I hope the Skywalk works out for them. My view of it is quickly cut off by the high walls in this narrow stretch and I refocus on the evolving scenery. Evolve indeed—what is that coming in on the right not far above river level in a cleft that seems to grade upward into a deep cave? It is something even more alien than the suspension bridges we passed under several days ago at Bright Angel creek.

Unlike any other place in western North America, we have travelled for 267 miles through scenic splendors without seeing the land significantly defaced by current or past mining activity. About to finish the journey, a bizarre, shiny scaffold clearly related to some kind of abandoned mine operation stands there fragile and rusting away (Fig. 21.11).



Fig. 22.11. Abandoned terminal for cable that extended across the river and 3,000' up to the south rim. Gondolas filled with guano from Bat Cave were to be hefted up to trucks that would carry it to Kingman. After 1,000 lbs were delivered, all was abandoned. An Airforce jet severed the cable in 1960.

That fragile looking structure was once the lower end of a 10,000 foot cable extending to the top of the rim on the south side almost 3,000 ft higher. This is Bat Cave, a huge cave discovered in the 1930s by a chap who boated up the channel after Hoover Dam caused this stretch to become navigable as part of Lake Mead. The top of the cave was covered with bats and the bottom with their excrement. Bat Guano was then valuable as much-needed fertilizer, and it appeared to be about 10 feet deep. Attempts to send out loads of it by barge failed because of floods and shifting sands. US Guano Corporation thus decided to bring it up to the South Rim by cable car where it could be readily trucked to the railroad at Kingman about 70 miles to the south. Production started in 1957, but it was discovered within a year that the amount of organic gold in the cave was only about 10% of the amount estimated. Production ended, but the impressive cable car system strung down across the Grand Canyon provided a spectacular location for major parts of the 1959 movie “Edge of Eternity” (Fig. 21.12).



Fig. 22.12. Climactic fight scene from 1959 movie “Edge of Eternity.” Lake Meade was backing up the channel then causing the river to lose velocity and deposit the sand bars visible here. With the decline in lake level, the river has now cut a channel into these deposits leaving steep shoulders along both banks.

A military pilot hotdogging down the gorge (as was common until the 1980’s) clipped and severed the cable in 1960 to end the story. Remnants of the cable car facility on top of the rim not far from the Sky Walk remain a tourist spot the Hualapai renamed “Guano Point” instead of “Batchit Mining Camp.” The mining hubbub is now gone; bats can return to their ancestral home.

The river is now opaque with muddy waters sluffed off the banks and rippled with waves from a boisterous wind that is steadily increasing. The water becomes dangerously shallow for our boat, and JP must constantly rotate the engine up toward him to keep the prop from digging into the muddy bottom. The active channel of darker, deeper water could be

seen earlier as it meandered between the mud banks. Frighteningly, wind-whipped water has ruffled the surface into dancing whitecaps. JP is mostly unable to read the surface of the water which can reveal a slightly enhanced current over deeper water. He is threading us slowly along through mudbanks now by instinct, occasional channel indicators, and maybe luck. He must stand down in the motor well ready to rotate the motor up above the mud but pops up over and over to see if there is any indication of where deeper water might be. He keeps saying, "This is terrifying" every time his head appears. We augur in several times, but this consummate boatman knows how to wiggle the tiller while pulling hard on the top of the motor. We thereby keep crawling along while the river gods underneath keep trying to grasp us. The muds so grieving us suggest that Hoover Dam was a Faustian Bargain.

Meanwhile, the walls of the canyon are getting farther away and often out of sight behind the high banks of gray mud. The wind keeps lambasting harder and harder. Small whitecaps sparkle, flit, and splash wildly as we head straight into the sun. Mists fly up into my face in the fast wind. The sky above and everything ahead is washed out by brilliant sunlight. High thin clouds cover the sky above us while the canyon walls are hazy, featureless, and increasingly recessed. The neck flap on my life jacket starts flipping up and pounding the back of my head rapidly, repeatedly, and ruthlessly. Pow! Pow! Pow! I pull the straps of my broad-brimmed sun hat painfully tighter and tighter to keep it from blowing away. The normally rigid front brim flips up again and again until I finally give up bending it back into place. I can hardly keep my eyes open in this wind, blinding sunlight, and gauzy sky. Suddenly and inexplicably, this distressed spectacle of nature becomes exhilarating. I stand up, grandly spread out my arms, open hands wide, and begin embracing all--a sort of ecstasy conditioned by the previous days and the expectation that we will soon burst out the end of the confining gorge. Immersed in wind, dust clouds wafting over the boat, gray walls of mud along both sides of the river, dead black jagged trees leaning over ready to fall, the brown water covered in flashing whitecaps, the boat pitching, mists flying, and that huge, huge, huge sky above-- I exult with uncontrollable yells and gestures again and again while JP pops up again and again saying, "this is terrifying." I suddenly realize that he may no longer be referring to the difficulties of navigation but rather to these antics. I sit down and shut up.

Over and over, I wish that the end is just around that next bend ahead. Suddenly, the wind slows--and there it is (22.13)! We are about to emerge from the canyon that had become a wind tunnel.



Fig. 22.13. The last bend of the Colorado River lies straight ahead to the left and is a welcome sight for weary river runners ready to exit the Grand Canyon.

After 278 miles, the walls end abruptly and we cruise out into Lake Meade. I take a last look at the portal we just passed through (Fig. 22.14).



Fig. 22.14. Looking upriver at the end of the Grand Canyon. JP Running is finally getting relief after many hours of navigating through the sediment-choked final stretches before freedom at Lake Mead.

JP is noticeably relieved for the first time since we left Lees Ferry. The responsibilities, stress, and physical effort exercised by a Colorado River Guide are enormous and underappreciated. He can soon relax. I feel like we have been through a universe and am physically and emotionally exhausted. Turning to face west again, the river is still confined in gray walls that block the view of isolated peaks and distant mountains in this new world. However, this is hardly the end of my pilgrimage. The Mojave Desert, Death Valley, and the High Sierras beckon!

Within 20 minutes, we see vehicles on the left including the Hatch semi-tractor trailer and a gin pole truck. There is my white FJ Cruiser! By prior arrangement with Steve Hatch, it was brought down on the big flatbed truck. The boat ahead is already deflated, and its iron-framed core is being hoisted onto the big truck (Fig 22.15).



Fig. 22.15. While loading the deflated and disassembled boats, my FJ Cruiser is brought down from a parking area. It is the end of the raft trip and the beginning for me of a journey across the Mojave Desert, up the entire length of Death Valley, and onward to the summits of the High Sierras.

We pull in and greet Tim Stephenson, a boatman I once did a raft trip with and who today is going to drive the disassembled boats and crew back to the Hatch warehouse. This is not the time and place to chit-chat and relive old times. The crew must break down JP's boat before cramming into the semi for a 350-mile haul back to the Hatch Warehouse. JP is doing a "burnaround." He will immediately rig his boat again and be on the water in 24 hours for his next trip. We do some quick hugs, handshakes, and goodbyes that seem curt in view of what seems like an epochal moment. There is no offer from me to help because I can only get in the way. Just like that, the raft trip is over. I throw my duffle into the FJ, wave, and drive uphill toward that huge, beautiful sky.