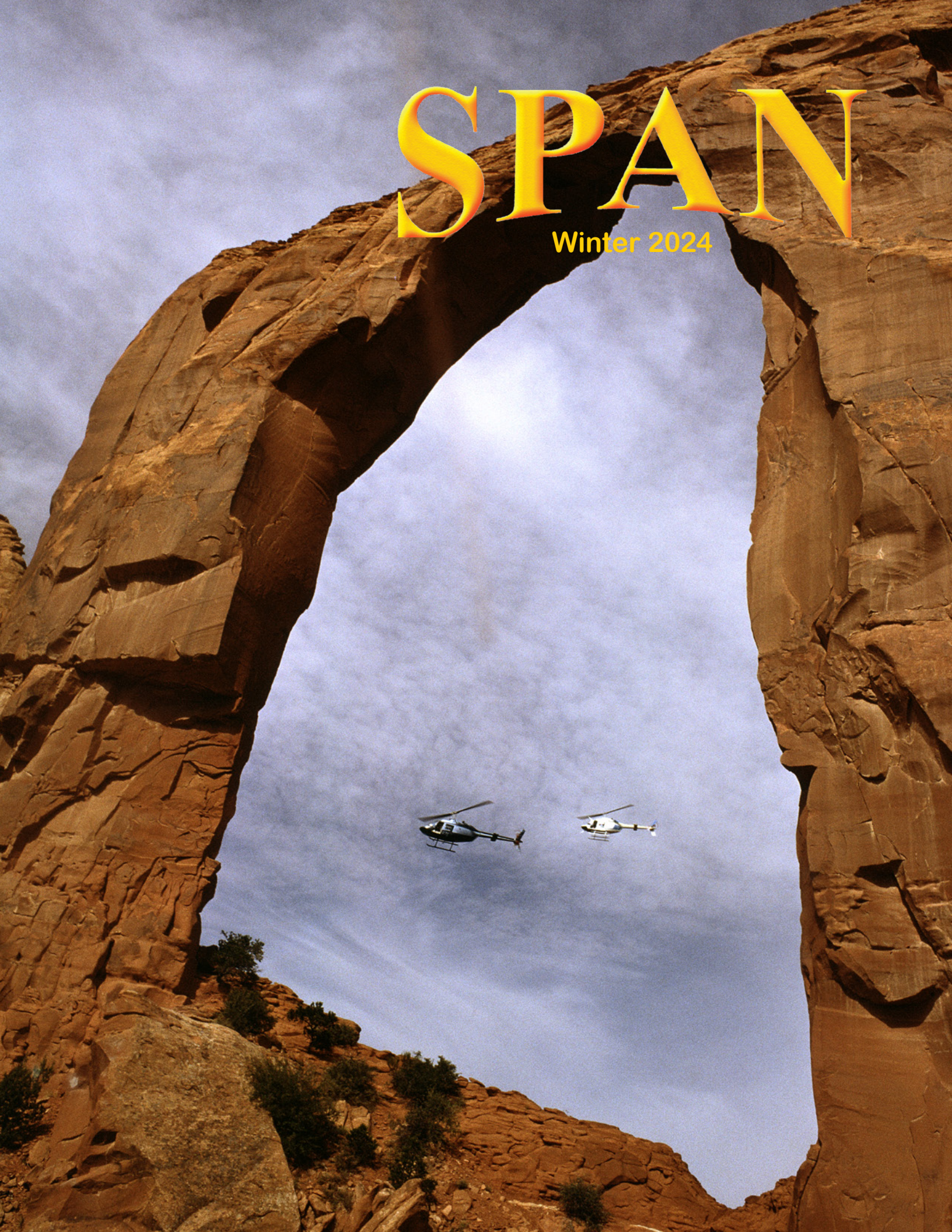

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Winter 2024

you to

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Newsletter of
the Natural Arch and Bridge Society

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President's Column

When I retired from The University of Miami in 2018 and Cynny (Scott) and I moved to Tucson, where we didn't know a soul, I was already the editor of SPAN, so I had a theoretical concept of NABS. To me, its members were fit intellectuals living the dream of exploring the Old West. They traveled on ancient washboarded stagecoach roads in search of metaphorical gold—natural arches.

Being retired and living in Tucson, the opportunity finally came for us to attend our first rally—Springtime in Moab, May 2018. We were naturally intimidated. In fact, the Friday before the start of the rally, we hiked to Druid Arch in Canyonlands, just to have something relevant to talk about in case anyone asked us if we had ever hiked to an arch before.

We stayed through the wonderful party that Bonnie Crysdale and Mike Duncan hosted at their house and got our first taste of Larry Beck's legendary strumming and singing. We experienced our first hikes led by David Alexander, who we still can't keep up with. We got to meet Rich Beckham and a bunch of Scotts, so name-wise, we felt right at home. We met Henk and Reina, who we later visited in Hoorn, their home in the Netherlands. We hiked with Henry Wede, Peter Jamieson, David Kennedy and others for the first of many times to come, and met such NABS legends as Evelyn Johnson and Tom Van Bebber.

And now look what's become of us. We own a Jeep, we're almost competent using our Garmins and we're planning rallies and hosting hikes. I've just finished my first year as President of NABS and have been designing and editing SPAN for more than seven years (with much help from David Kennedy and David Brandt-Erichsen). NABS now has a Hall of Fame and we had a wonderful induction ceremony in Colorado where Cynny and I shared an AirBnb with Jay and Judy Wilbur. Jay (a co-founder of NABS) and I share a favorite beer in addition to many other things. And, NABS is getting ready to have its first international rally in more than a decade.

We've already recruited a dozen family members and friends to join NABS and we now plan road trips using Google Earth and waypoints instead of road maps. Somehow, there's always an arch worth finding (or not) between here and there.

We still don't know a soul in Tucson, but NABS has made us feel at home in the Southwest and for that I want to thank all of you. I hope to see many of you at the upcoming rallies in Arizona, France and California.

Rich Beckman
President

Cover: Royal Arch (V11-8, 12S-657183-4052730, 76'x170'), Navajo Nation, AZ. Prior to the formation of NABS and the first issue of SPAN (August 1988), Dr. Stephen C. Jett flew through Royal Arch in a helicopter. Fascinating excerpts from his journal begin on page 3.
Photo by Dr. Stephen C. Jett

Elephant Arch (V11-3, 12S-665230-4058150, 15').

Airborne Arch Adventures: Excerpts from a 1985 Diary

Text and photos by Dr. Stephen C. Jett

Since the late 1950s, I have been conducting research on the Navajo Indian Reservation, especially at Arizona's Canyon de Chelly National Monument and in the nearby Chuska Mountains; for many years, I have maintained detailed diaries of my expeditions.

In the course of my Reservation travels, I have encountered numerous natural arches, some not previously described. In the first selection below, from a 1985 diary, one of these little-known openings and its surroundings are portrayed. The Tunnel Trail mentioned descends from the first, westernmost Canyon de Chelly south-rim overlook; Cottonwood Canyon (Navajo T'iis Nanít'i'í Nastł'ah) is a tributary whose mouth is on the opposite side of Canyon de Chelly from Tunnel Trail. Cottonwood, which is fault-controlled, has two parallel forks. Note that any non-resident who wishes to enter the canyons must be accompanied by an authorized Navajo guide.

Aug. 25

We [Londoner Patricia "Tishy" Nugee, and myself] went down Tunnel Trail with [a teacher at a Nazlini, AZ, school,] Keith Franklin, and [with] Max, a volunteer [National Park Service] ranger. In [a] cave on [the] outside of [a] bend of [the] right branch of Cottonwood Canyon [looking upstream] is a [pictograph] panel of yeis [yé'ii, Navajo supernaturals]. Only two are fairly distinct, but vestiges of eleven are visible and smoke-blackening covers where a twelfth one probably was [12 is the standard number].

Up [the] other branch a short way, on the right, is a cave with a small ruin. An opening in the back of the cave leads to another fault-line cave, with an outlet at right angles. This cave is now used for hay storage. Someone has written "Teller Window Rock" over the arch. On the inner cave ceiling is a "planetarium" [a Navajo pictographic star ceiling, with usually cross-shaped star depictions on the roof], including round "stars" in both black and tan, and both black and tan[-painted] three-pronged "stars" showing evidence of ties [the "stars" were made with yucca-leaf stamps, the stamps' plural parts sometimes bound together]. One tan circle appears to have charcoal markings on it; a ladder would have been necessary to reach it. There are also [Anasazi/Ancestral Puebloan] mud balls on the wall next to the arch and a red-ochre arc over the arch. Under the opening are two Anasazi pictographic figures and

Blackhorse Arch, V11-2 (12S-662460-4062690, 87'x52').

some mud balls. There is evidence that the opening had once been walled up. There is a Navajo burial cist built against the ruin wall. It is roofless but is filled with sandy earth. A [human] knee joint is exposed, as is a piece of buckskin. Perhaps the Tellers [the local Navajo family] aren't afraid of chindi [in Navajo religious belief, the ghost left behind after a person dies], because they're Presbyterian.

Around the corner, also on the right, is a[nother] "planetarium." It is all done with black and includes large and small crosses, a couple of crescents, armless "figures," [and] crosses with two arms barred. [Many star-ceiling figures were created by the paint-covered stamp being shot upward on the end of an arrow.] I could not identify any arrow nicks, although a number of crosses had light spots in the center. Perhaps the arrows (if that's what were used) had wooden tips.

In the sand of the cave floor, someone had made a foot-high cone of sand, I suppose by pouring. Whether it was done just for fun or as a ceremonial sand mountain was the question. No prayer sticks were in evidence. There were a few secular Navajo drawings on the cave walls.

Because of my decades-long experience of the geography of Navajo Country's scenery, I was invited to guide a media group on a helicopter tour of the Four Corners area. One of the three pilots, a wild 45-year-old flyer and weathercaster named Jerry Foster, was from Phoenix's KPNX-TV Channel 12 and had been a friend of, and occasional pilot for, Senator Barry Goldwater (Sorg 2013); he and his producer had brought a cameraman to shoot scenes for short features on Phoenix news shows, notably "Live at Five." Also along were Ed Mell, a noted landscape painter of the Colorado Plateau; Donald J. Hagerty (1934–), a historian of Western art from the University of California, Davis (my own institution), and chronicler of, among others, painters Maynard Dixon (1875–1946) and Ed Mell (1942–); plus photographer and writer (and competitive practical hand-gun shooter) Nyle Leatham (1930–2007). For another mention of this expedition, see Hagerty and Mell (1996: 56–57, 117, 119). The Phoenix party had flown in to Chinle, AZ, where Tishy and I were staying, and it was from the airstrip there that we departed in the morning.

Aug. 26

The Phoenix people didn't realize that [unlike the rest of Arizona] the [Navajo] Reservation is on Daylight Time, so I had to wake Don up at 6:30. We breakfasted in the [Thunderbird] Lodge and then drove down to the airstrip. The [Sky 12] helicopters were there. We unloaded some gear from them and removed a couple of doors to minimize weight and fuel consumption. Then we warmed up and took off. I sat as "navigator" in the front of Jerry Foster's "bird." Tishy and Susan Berry, the producer, sat in back. In the other helicopters were Wilbur (the other TV-station pilot), Don Hagerty from Davis, Phoenix artist Ed Mell, Dick (regional Bell Helicopter rep), a young TV cameraman, and Nyle Leatham (Arizona Republic columnist and photographer). [My Navajo consultant] C.N. [Chauncey Neboyia; 1909–2006] came to see us off.

We flew northward. Our first goal was Round Rock, and we approached it over the extensive red Painted Desert badlands on its south side. I told the Navajo story about the origin of the natural arch [Window Rock; V11-9, 12S-629195-4040060, 60'x130'], and we hovered next to it briefly. The other TV copter hovered on the opposite side to film Jerry's through the arch. Then to the pinnacle at the rock's northwest end, where Jerry touched down briefly; I was chagrined to see remnants of climbers' ropes bolted to the summit.

Unfortunately, the sky was partially overcast and the air hazy. Still, it was pretty spectacular to see these monuments from alongside and above.

We proceeded to the canyons fanning into the base of the Lukachukai [Mountain]s and buzzed one ruin and then landed at Vandal Cave. There are three or four vertical-slab-and-adobe storage cists, some in a pretty good state of preservation. There were corncobs but no potsherds, indicating a Basketmaker II age. The TV people interviewed me about the ruin, its age, the peoples' livelihood, etc., and about my opinion of pothunters [illicit excavators].

Then off and up, over Rotten Rock Ruin and across a couple red-rock canyons to the tall [buttress-type] natural arch [Los Gigantes Arch, V11-4, 12S-653098-4054469, 65'x120'] beyond Buttress Canyon. It is quite large and impressive when viewed up close and [from the air]. From there, we flew over the mesa and down into Red Rock Valley [now, Red Valley] at Royal Arch [V11-8, 12S-657183-4052730, 76'x120' (see cover)]. The big almost freestanding opening intrigued Jerry and he flew [us] through it twice, from east to west, for the camera copter to film. It was a novel sensation, to say the least.

We went on to Prayer Rock [a pinnacled mesa in Red Valley], inspecting the precarious little window in its south base [since-fallen V11-6, 12S-659740-4054110 (f)], continued along the rock's east side past the tall pinnacle, and then flew on across the valley to "Elephant Arch" [Elephant Rock, V11-3, 12S-665230-4058150] on a slickrock spur jutting southward into the lower country. There, we landed, admired the arch, the scattered round boulders around it, and the broad view of Red Rock Valley and the blue Lukachukais beyond. The cameraman had the three "birds" do a couple of flybys in formation, to be shot by and through the opening.

At one point, I felt obliged to ask Jerry not to fly too close to arches lest the engine vibrations do damage.

It was necessary to refuel, so we headed toward Farmington, NM. The San Juan Basin was sere and unattractive, and to the east the air was befouled by smoke from the Four Corners Power Plant [Four Corners Generating Station; scheduled to be decommissioned in 2031], but it was very exciting when we circled Ship Rock [Pinnacle] twice. Its tremendously high fluted sheer sides, its two [bird-droppings-splashed] pointed peaks and other projections, the long black walls of its [two radiating] dikes, and the dark columns rising off its northeastern side were an unforgettable ensemble as seen from the helicopter.

We flew by an opening in Shiprock's dark West Dike.

At Farmington airport we lunched in the restaurant while they "gassed up the choppers." Then back westward to Red Rock Valley, where we circled a nice arch [Blackhorse Arch, V11-2, 12S-662460-4062690, 87'x52'] near the head of one of the south-running canyons. (See photo on page 4.) All of these arches, except Royal, were first reported in print by me in my dissertation.

Then [we flew] north over a little canyon with a thin waterfall and across the divide into Seklagaideza [Navajo, Tséłgai Deez'áhí, 'The White-Rock Point'] Canyon. The [geography of the] country here is characterized by strata sloping westward from the Carrizo [Mountain]s, dominated by dusty red cliffs of the Carmel Formation. These become more horizontal to the west, where their thin, often contorted, bedding shows up well. The inner gorges are in Navajo Sandstone, and we spotted one little ruin dominated by a circular structure with peculiar masonry—the stones looked rounded like river cobbles.

We got separated from the other two copters about this point. Ours, I directed toward Alcove Canyon. There were a few dirt tracks in these canyons. Alcove was very shallow where we hit it, with a substantial arroyo, but became increasingly deep and narrow as we proceeded up canyon. The sides were undercut with broad, arched caves. I saw one small ruin on the left and then suddenly a good-sized one. I pointed it out to Jerry, who was quite excited. It was in two parts, at either end of the cave. To the left were some

walls, rather ruined with regular loopholes, and to the right a little cluster of cubist rooms. We tried to hover for a photograph, but the dust kicked up by the prop wash inhibited picture taking [and threatened the engine]. Unfortunately, without the other copters, there was no TV taping. I assumed this was Promontory Ruin [it was; Bernheimer 1999: 158–59].

We took off up-canyon, swinging back and forth around the bends in the handsome Navajo Sandstone gorge. It was very beautiful and exciting. We went up one of the numerous branches of the upper canyon system, topped out over its head, and flew southward by . . . [square-shouldered] Los Gigantes Buttes. Off to the east, the blue Lukachukai Mountains with their [Wingate Sandstone] red-cliff base were overhung by a great cumulus cloud threatening rain.

We flew on southward and finally landed once again at Chinle airport. Tishy and I drove up to Imperial [Mart] and brought back some cold pop. After repacking and imbibing, the others took off for Monument Valley and Page. We returned to the motel and napped.

I never learned whether or not any of the footage shot on this jaunt ever appeared on television. Following repeated requests for a videotape of the expedition, I finally received a VHS tape containing a great hodgepodge of images of numerous things, including just a little bit of our trip.

Foster was "famous statewide for his flamboyant flying," and by 1990 was reported as having been cited at least five times by the Federal Aviation Commission for infractions. Later in the year of our flight, he is said to have almost lost his license for aerially harassing a pilot in a small plane erroneously believed to be a suspect in a bank robbery. Jerry Foster is also reported to have been investigated in the mid-1990s when a small amount of marijuana fell out of his craft at a public appearance (Hostetler 1990). According to Wikipedia, this incident got him fired from his then employer, Phoenix's KTVK Channel 24. He also hung out with biker gangs and was caught on a police camera purchasing an amphetamine and lost his job. His autobiography is Foster and Dees 2013 (which does not mention this trip). Jerry died of cancer in March 2023, at age 82 (Ruelas 2023).

To continue with the day's activities:

After the "kip," as Tishy calls a nap, we drove out past Spider Rock and turned down the Three Turkey road. We parked at the wash and hiked down the very shallow canyon. Much of it was paved with pink slickrock. About a mile and a quarter down, the wash suddenly drops into a short narrow inner gorge, which exits into a now fairly deep canyon with lichen-splotched broken walls. The amazing thing is that a short way below the commencement of the real canyon, an almost flat natural bridge, wide enough for a small two-lane highway, spans the canyon at about mid-elevation of the walls. As if this weren't enough, low in the inner gorge above the big bridge, at the gorge's mouth, is a small flat stone span across the stream. Both of these bridges are of resistant layers of sandstone. [This is Three Turkey Natural Bridge, 12S-644551-3987068, 50'x22'.] I heard of it from Keith Franklin. There is also a previously unrecorded, modest-sized natural opening in lower Three Turkey Canyon, relatively easily reached on foot from a dirt road that approaches the canyon mouth. [A Navajo Nation Back Country Permit may be required to visit it.]

A natural window in Round Rock, AZ (from helicopter). Round Rock, also known as Tsé Nikani (Flat Plated Rocks) in the western part of the Navajo Reservation and Bis Dootl'izh Deez'ahi (Blue Pointed Mesa) in the eastern part, is located on the Navajo Reservation in Apache County, AZ.

Dr. Jett is Pofessor Emeritus at the University of California, Davis, where he chaired the Geography Department on three occasions.

(Journal references available on request: scjett@hotmail.com).

The Lost Bench

Text and photos by David Kennedy

One of the hikes offered during the rally this past fall in Mesa County, Colorado, was to see Bench Trail Arch. As luck would have it, the NABS members who signed up for the trip didn't get to see the arch. Bench Trail is an unofficial trail in the monument, so there are no sign posts anywhere for it. A critical right turn was missed and the hikers got to see incredible red rock and Colorado River valley views but not the arch.

In the lead-up to the rally, I took a day in August to scout the trip with the intention to get into the arch, which is situated well above the trail. I had always viewed it from below on the trail in my other two or three trips.

Starting early from the trailhead off Wildwood Drive in Grand Junction's Redlands district to beat the heat, I climbed steeply up the trail until finally reaching the bench for which the trail is named. I don't know if the bench was formed because of the Redlands fault or some other geological or environmental force, but it is a reasonably flat and wide corniche between the cliffs at the valley level and the cliffs above upon which the petrified sand dune Liberty Cap sits. Where the Ute Canyon Trail splits left at a signed junction, I turned right to stay on Liberty Cap Trail. About 100 yards northwest of the signpost, Bench Trail takes off to the right but the intersection is on a mound of decomposed granite which doesn't show tracks, making the turn very difficult to see.

I missed this same turn as the hikers in the rally missed and started ascending toward Liberty Cap. Having been there before, I soon realized my error and spotted the trail I wanted about 50 feet below. I went down cross-country to the trail and continued toward the arch. It's a good thing I had a fix for the arch in my GPS because it was quite a bit farther to where I could see the arch than I remembered. The trail had been washed out in several places but it was easy to see where it continued on the other side of the wash outs.

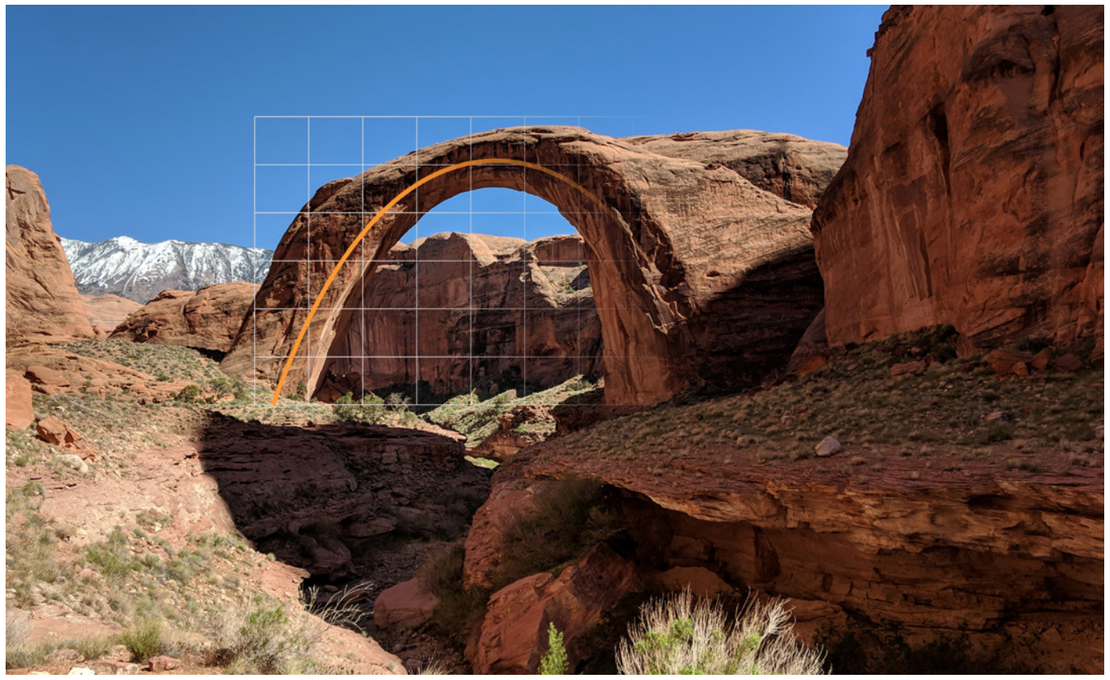
Eventually I got to where I could see the arch way above in the cliffs and began to look for an off-trail line that would take me up to it. It was a very steep climb through juniper and pinyon trees and their attendant shrubbery and cactus plants. On the way I stumbled upon a small cave-type arch which had not been recorded. For want of anything better I called it Bench Trail Cave Arch (12S-700479-7326969). I measured it at 8'x3.5'. Arriving finally at Bench Trail Arch, I began to move around and photograph it from various aspects. It didn't take long for me to realize that it is a much more worthy, interesting and photogenic arch than I was expecting. Strangely, photographing it from the right side changed the perspective from horizontal to vertical.

Bench Trail Arch (12S-700430-4326910, 20') in the Colorado National Monument.

The World Arch Database typifies Bench Trail Arch as an alcove arch, but in my opinion, it should be reclassified as a waterfall natural bridge. There is a definite stream course through the arch and continuing down the slope. I tried to find a way to get on top of the span and located a couple of possible routes that I didn't attempt because of my solo status and some moderate exposure to falling. In doing this scouting I noticed that I could see light through a strip of rock (12S-700450-4326924) clinging to the cliff face off to the left of Bench Trail Arch. I got to where I could get a fairly decent photo but its inaccessibility made it impossible for me to do any measuring. I decided to call it Thong Arch because the "T" shape of its rock formation reminded me of the toe thong on a beach sandal. It appears to be a propped-type arch.

On the way back to the trailhead, I diverted a short distance on Ute Canyon Trail for a look at Ute Crossing Arch (12S-701863-4325713). It looks like an interesting span, but I've never been able to find an access to get to it. My viewpoint was at 12S-701913-4325761.

Back at the car park my GPS had recorded a track of 5.68 miles for the day.



Rainbow Bridge with a catenary curve overlain (fading right).

Rainbow Bridge, a Structural Anomaly?

Text and graphic by Dr. Jeff Moore

Rock is weak in tension, therefore an ideal arch form is one that minimizes tension and carries the weight of the lintel in compression. For centuries that form has been known to engineering as the inverted catenary, or an upside down version of a hanging chain. In an inverted catenary, stresses are mainly compressional and manmade arches can be constructed from interlocking masonry alone. In natural arches, the lack of tensile stresses helps minimize crack growth aiding arch stability and longevity. However, natural arches evolve through erosion and the sculpture is often imperfect. Features in the rock mass like joints and bedding can impart strong control on arch shape, and an arch rarely has the opportunity to evolve into an ideal stress-based form.

Our team from the University of Utah, Department of Geology & Geophysics, recently conducted a study* where we analyzed the static, gravitational stress conditions in 19 aches from southern Utah, representing a range of lengths from 4 to 88 m and a variety of forms. We used 3D models created from photogrammetry with material properties previously calibrated from dynamic analysis of ambient vibrations. Notable arches analyzed include Delicate Arch, Landscape Arch, Owachomo Bridge and Rainbow Bridge. Some basic results were intuitive: arches shaped like a flat lying beam have tensile stress concentrations at the bottom center of the lintel and on the top surface near the abutments, as expected from beam theory. Owachomo Bridge and Musselman Arch are two examples, and in many cases, cracks can be found on the underside of the arch in these areas.

To help quantify the relative amounts of compressive and tensile stresses for each arch, we extracted the maximum and minimum principal stresses on a regularly spaced grid. Generally, the maximum principal stresses are compressive and the minimum are tensile (following the geoscience sign convention). We then took the mean of each and related these as a ratio, max/min, which we label the mean principal stress ratio (or MSR). The MSR value describes the overall stress conditions for an arch; for example, in a theoretical flat-lying beam, tensile and compressive stresses are equally balanced and the MSR would be 1. For an inverted catenary, tensile stresses would be minimized and compressive maximized, resulting in a large MSR value.

One intriguing result stood out in our analysis: of the arches studied, Rainbow Bridge had the highest MSR value meaning it has evolved a form more like an inverted catenary than any other. The form is in fact a very close match to a theoretical inverted catenary (described by a hyperbolic cosine function) and neatly reduces tensile stresses throughout the bridge lintel. Over thousands of years, Rainbow Bridge has self-sculpted into a nearly perfect stress-based form. A high quality rock mass with few discontinuities has been crucial to support this evolution, allowing the arch to shed portions of rock held only in tension. However, all is not well for Rainbow Bridge. Our analysis also revealed that the arch is leaning, bending toward the northwest direction (toward Lake Powell), and pulling away from its abutment on the south side of Bridge Creek. So while one aspect of the form is near perfectly sculpted, the in-plane form, the arch suffers in the out-of-plane direction leaning outward. Could toppling be its ultimate mode of failure? Time will tell.

* A full text of the paper can be downloaded from our group website:
https://tinyurl.com/4ssc3y28

Dating the formation of Rainbow Bridge

Text by Dr. Jeff Moore

Determining the timing of arch collapses is increasingly viable with the availability of photo documentation, but determining the timing of arch formation, and thus the age of an arch and duration of its evolution, is rarely feasible. Arches form through incremental erosion often over thousands of years, but the moment of birth – the first collapse creating the nascent opening – is most often a small event rarely witnessed, and thus opportunities to date this first formation are few and far between.

Our team from the University of Utah, Department of Geology & Geophysics, recently visited Rainbow Bridge, Utah to perform field work collecting samples for cosmogenic nuclide depth profile dating in order to help determine the age of formation of the bridge. While we won't have results for a while, we're sharing a project status report and update.

Rainbow Bridge formed through undermining and puncture of an entrenched meander bend by Bridge Creek*. The creek would have formerly flowed around a wall of bedrock following a meandering path, traces of which are evident today in the topography of the walls of Bridge Canyon and by a series of alluvial terraces deposited as it rounded each bend. When Bridge Creek punctured through the wall of rock, giving rise to the nascent Rainbow Bridge, these terraces were suddenly abandoned. We aim to date the abandonment of the terraces as a means to date the formation of Rainbow Bridge.

The dating technique we adopt relies on measuring the concentration of exotic nuclides of Beryllium (10Be) created in minerals (predominantly quartz) by bombardment from cosmic rays. By collecting several samples of sand from different depths in a shallow pit, we aim to reconstruct a curve of decaying 10Be concentration which can be used to determine the age of terrace stabilization, i.e., the age of abandonment. The technique is well tested in a variety of environments across the world.

We approached the National Park Service with the idea several years ago, and were able to brief the Native American Consultation Committee at Rainbow Bridge and incorporate their feedback, and in addition work with Park Service archeologists to ensure we weren't disturbing any artifacts or archeological sites. We were ultimately granted permission to dig two pits, one on the terrace directly adjacent to Rainbow Bridge and the other on an terrace upstream.

After several years of postponement due to the pandemic and low water levels in Lake Powell, we were finally able to conduct field work this summer, digging the two pits as planned and collecting 14 samples of sand (each sample is the size of a Ziploc bag). Digging these pits in the rocky ground was very difficult, each requiring about eight hours of work from our team of five. The samples we collected will undergo chemical preparation this winter, with accelerator mass spectrometry analysis to follow in spring, after which we will be able to know whether we are able to successfully resolve the age of each terrace and thus the birth of Rainbow Bridge. Stay tuned for updates!

*Chidsey, Jr., T. C., Willis, G. C., Sprinkel, D. A., & Anderson, P. B. (2000). Geology of Rainbow Bridge National Monument, Utah, In: Geology of Utah's Parks and Monuments Vol. 28 (eds D. A. Sprinkel, T.C. Chidsey Jr., & P.B. Anderson) 251-262, Utah Geologica Association, Salt Lake City, Utah.

Photo by Molly McCreary

Researcher sampling from pit on upper terrace.

Arches of the Bohemian Paradise

Text and photos by Dr. Vlastimil Pilous

Rainbow Arch (Duhová brána, 33U-504709-5595977).

The Czech Republic is a small country in Central Europe (a bit larger than South Carolina). The southern half of the Republic is formed by crystalline complex rocks and granite, which are rocks that are unfavorable for the formation of arches, and therefore, there are almost none in that part of the country. However, a significant part of its northern half (north of the capital city Prague) was filled with a shallow sea during the Cretaceous period. Several hundred meters thick layers of sandstone settled at the bottom, which, after the retreat of the sea, underwent various intensities of erosion. This area is called the Bohemian Cretaceous Basins (orographically Czech Table). Due to this erosion, numerous extensive groups of tower-like rocks were formed, known as "rock cities" in Czech. In English, an adequate term for these formations was lacking until recently, but the term "rock cities" has recently been introduced even into specialized English geomorphology.

They could perhaps be compared to Bryce Canyon, but due to the local moister climate, they are significantly more wooded, and many rock formations are hidden by pine and beech forests. Whereas most European arches are limestone, The Czech Republic is the exception, where the majority of arches are in sandstones, similar to the USA.

Thanks to this Bohemian Cretaceous Basin, the small Czech Republic has perhaps more rock cities than any country in the world. Their largest concentration is located in the area between the cities of Turnov and Jičín, about 70 km northeast of the capital city Prague. Due to its extraordinary beauty, this area is called the Bohemian Paradise (Český ráj in Czech). The sandstone rock cities here are combined with numerous volcanic rock formations, as well as many historical landmarks, such as medieval castles (some of which are largely carved into rocks and called rock castles), old folk architecture, or ponds. In the sandstone cities and rocks of the Czech Paradise, several dozen rock arches and windows have been formed, of which only a few of the most significant and interesting are listed here. Although they are mostly smaller in size, many of them have interesting, sometimes quirky shapes.

The symbol of the Bohemian Paradise is the medieval castle Trosky standing on a pair of tall volcanic buttes, but the most significant shape of the local landscape is the sandstone rock cities, which are the most concentrated in the whole country. Therefore, there are also the most rock openings, arches and windows. On the

Bird's Kiss Arch (Ptačí polibek, 33U-504743-5596153).

Krtola (33U-504039-5597489, 7m x 10.5m).

slopes of Trosky, there is the only lava tunnel in the Czech Republic (33U-516361-5596093), although it is very small in size.

In the rock city of Přihrazské skály, there is the unusual Rainbow Arch and the uniquely shaped Bird's Kiss Arch (see photos on page 10). In one of the local ravines, there is the Big Arch (Velká brána, 33U-505772-5596882) the second largest in Czechia after Pravcická brána (see SPAN November 1992). Its opening reaches a height of 10 m and a width of up to 7.5 m. Nearby is the Column Arch (33U-505858-5596884) intersecting an isolated rock column. Also relatively large is the arch called Krtola, which formed in the wall of a canyon by the collapse of the ceiling of a pseudokarst cave. In the peripheral part, there is the interesting Hope Arch in a solitary rock.

Several interesting arches and windows are also in the rock city of Betlémské skály, which smoothly transitions into Klokočské skály. One of them is named Three Legs Arch (Trojnožka,33U-513480-5605722), and there are also openings in another unnamed rock nearby. The Double

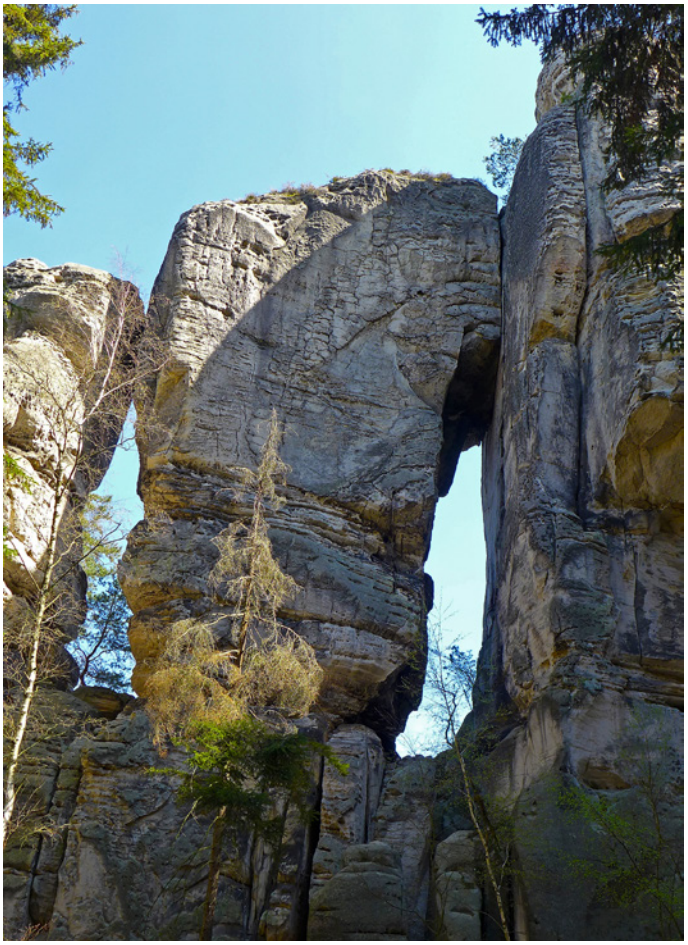
The medieval castle of Rotstein, partly carved into the rock includes a large rock window (33U-515867-5604719).

Rock Window is also interesting (Dvojité okno, 33U-513618-5606005). In the local rocks, there are also several pseudo rock gates, formed by wedging fallen rock blocks into narrow crevices. On the edge of this rock city is the medieval castle Rotstein (see photo on page 11), partly carved into the rock, and it includes a large rock window.

One of the largest and most beautiful rock cities is Hrubá Skála, where there are also several rock gates. The most famous is Bránicka, along the tourist path, and others are in a group of rocks called Maják (Pharos). One of the highest rocks here is Dragon Tower which contains the highest arch in the country. Also interesting is the rock gate Elefant, under which there is another small opening (Slon, 33U-513129-5599353). Among the most famous is the Drahonovská Arch on an isolated rock, which is easily accessible.

Several rock gates are also located in the canyon of the Jordánka (Yordanka) stream, the largest of which is Zheleiovska Arch and others have a "Gothic" profile in the lateral Tachovské údolí (Takhov Valley). There is also one of the few rock bridges over a stream in the Czech Republic, but it is also of small dimensions.

Under the Trosky castle, there is the miniature rock city Apolena, where there are also several arches within a tiny area.



One of the tallest rocks in Hrubá Skála is Dragon Tower (Dračí věž, 33U-513794-5599532, 1-3m x 30m).

(Top) Maják (Pharos, 33U-512134-5600831).

(Above) Zheleiovska Arch (Želejovská brána, 33U-514352-5595624).