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**MEASURING THE SPAN OF THE
GREAT ARCH AT ZION NATIONAL
PARK, KOLOB SECTION**
Reed H. Blake, PhD
Brigham Young University 6/84

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MEASURING THE SPAN OF THE GREAT ARCH
AT ZION NATIONAL PARK, KOLOB SECTION

Reed H. Blake, PhD
Brigham Young University

July, 1984

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8/16/84
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MEASURING THE SPAN OF THE GREAT ARCH
AT ZION NATIONAL PARK, KOLOB SECTION

Four parties have measured the Kolob Arch in the northwest section of Zion National Park. They are Fritz/Riley and Ayres/Creswell in the early 1950s and Blake/Naylor and Stevens in the 1980s.

Background

There is no record of who first discovered Kolob Arch. By the 1920s, people in Washington and Iron counties were generally aware of the arch, although it was seldom discussed. Otto Fife, for many years the sheriff of Iron County, recounted that his brother Arthur, who taught geology at both Utah State University and Southern Utah State College, visited the arch a number of times, including one hike to the spot with Dr. Frederick J. Pack, a geologist at the University of Utah, in the early 1920s.

During this time, the arch was within the boundaries of Zion National Monument. Access to the arch was difficult, as there were no established trails.

Nevertheless, through the years, interest in the arch grew, and people were making their way to the arch despite the hardships. During this time, too, interest grew in the size of the arch.

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Measuring the Arch

Efforts to measure the arch fall into two general time periods, the early 1950s, when the arch was still in the old Zion National Monument, and in the early 1980s. Measurements in the first period were by parties from outside the state of Utah. The second period, 1983-84, saw measurements by two parties from inside the state of Utah, both associated with Brigham Young University.

The 1950s Efforts

The first to measure the arch was Victor R. Fritz and George H. Riley, both of Philadelphia. They were assisted by Wilford B. Morris, 18, of Logan, Utah.

This party was in the canyon from July 9 to July 14, 1952. They measured the span of the arch from beneath, using a 50-foot steel tape, on July 11.

Fritz reported the arch has a span of 315 feet. In his written account, Fritz declared Kolob Arch to be "the largest natural span in the world." A copy of Fritz' visits to the Kolob section is on file at Zion National Park. It is a 14-page, typed manuscript detailing five visits--the first in August, 1951; the second in July, 1952; the third in July, 1953; the fourth in July, 1954; and the fifth in September, 1954.¹

¹Victor Fritz made a sixth trip to Kolob Arch sometime around 1957. It was on this trip that Fritz died of a heart attack

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Limitations. Kolob Arch hangs high on the wall of the canyon and is not attainable from beneath except, perhaps, by qualified mountain climbers. To measure the span from beneath, as did Fritz and Riley, one has to estimate the approximate spot (to begin measuring) by sighting down from one buttress to where the surveyor stands. Then to repeat this process at the base of the other buttress.

A further limitation is that the ground between these two points is broken and uneven, making it impossible to keep the tape even. Finally, there is the condition of sag.

Thus, the Fritz/Riley measurement can be considered a good estimate of the span of the arch, but not an accurate one.

Ayres/Creswell Measurement

The second team to measure the arch did so the following summer. They were Fred D. Ayres, a professor of chemistry at Reed College (Ore.) and avid mountain climber, and A. E. Creswell, a high school science and mathematics teacher in Oakland, Ore., who often climbed with Prof. Ayres.

They are the first known climbers to scale to the top of Kolob Arch.² Their measurements were made from above the arch.

during the night following a visit to the arch. He was found dead in his sleeping bag at his base camp by two traveling companions.

²In 1954, Fritz successfully made the ascent. He was accompanied by Justin Pierce and Leonard Kalal (or Kallal), both of

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The Ayres/Creswell account (written by Ayres) is published in the American Alpine Journal (1954, pp. 88-93), under the title, "Ascent of the Natural Bridge, Zion National Monument."

They measured the span on August 14, 1953 by taking parallel compass bearings on each buttress and then measuring, along the top surface of the bridge, the distance between the two sightings. "The top surface of the bridge," Ayres wrote, "slopes downward from south to north at an average angle of about 20 degrees. This was taken into account in calculating the horizontal length of the opening, the latter being a little less than the distance between our sightings as measured. The final figure may be called the 'span' of the arch."

Ayres and Creswell estimated the span to be between 290 and 310 feet, a figure they said they "believed to be conservative."

Limitations. Because of the large amount of chunkstone lodged between the buttresses of the arch and the canyon wall on which the arch clings, it is difficult to sight accurately the point at which the arch stands free of the wall. Beyond that, the Ayres/

Boulder, Colorado.

In 1984, the Stevens party made a successful ascent. The members of the party were Dale Stevens, Kelly Nielsen, Perry Hardin, Carl Horton, Reed Blake, and Spencer Blake.

The route taken by all three parties was set by Fritz and Riley in 1951. On this attempt, they were unable to reach the top, however, and turned back. This episode was again repeated in 1952; their high point was about 100 feet short of the top of the shelf

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Creswell measurement only sets the range of the span; that is, between 290 and 310 feet, with the qualifying statement that it is felt to be a conservative figure.

The 1980s Efforts

Two efforts to measure the arch were made in the 1980s. The first was at the invitation of the National Park Service and was made by Blake/Naylor in July, 1983. The second effort was by Dale Stevens and his party in May, 1984.

Stevens Measurement

The Stevens party consisted of Dale J. Stevens, geographer; Kelly Nielsen, cartographer; Perry Hardin and Carl Horton, both geography students and mountain climbers; Reed H. Blake, sociologist, who guided the party to the arch; and his son Spencer, who joined the party in the canyon on the second day. All were from BYU.

The Stevens measurement was made on May 8. He reported the span to be 292 feet.

The span of the arch was measured by lowering a 5-meter rod down from the top of the arch on the back side and then photographing the arch and the hanging rod from a position approximately a quarter-mile away on the north (right) side of the canyon wall, since a direct picture of the arch is impossible to shoot (unless by

that leads to the level of a small valley that gives access to the top of the arch.

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helicopter).

Stevens has written an account of his efforts under the title, "The Dimensions of Kolob Arch in Zion National Park, Utah." It is in typed manuscript form and is available from the author at the Department of Georgraphy, Brigham Young University.

Limitations. Photographic measurement is generally frowned upon by specialists in the field because of the numerous errors that have to be corrected for. (No corrections were made by Stevens.) For instance, perspective corrections (there is a 10-15 percent error in single position photography) would add 30 feet to the 292 feet arrived at by Stevens, making the corrected distance of the span 322 feet.

Other specific corrections that would need to be made in the Stevens technique, that would both add and substract inches or feet to his base figure, are related to the thickness of the caliper used in the calculation and the size of the photograph, the fact the rod was hung from the back and not the front of the arch, and that the angle of the hanging rod was not at a 90 degree angle to the camera.

Normally in the photographic measurement technique, since the ends of a picture fade in relation to the center, two pictures are taken of the object, centering on a right and left position (in this case, the arch). These pictures are then projected by

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two projectors into a single matched photograph--thus the relationship between the two pictures is more precisely known. In short, this is a type of photographic triangulation.

Blake/Naylor Measurement

Reed H. Blake and Clyde R. Naylor and a party that totaled 16 people measured the arch on July 28, 1983, using electronic distance measuring equipment mounted on a Zeiss theodolite.

The survey crew consisted of Naylor and three civil engineering students from Brigham Young University, Bradley C. Babcock, Reed R. Murray, and James Williams.

They determined the span of the arch to be 310 feet, a figure that Ayres and Creswell also reported.

The following is a detailed report of the Blake/Naylor effort, including the report filed by the engineers.

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SUMMARY OF THE BLAKE/NAYLOR EFFORT

The Blake/Naylor effort to measure the arch began in March, 1983 when the acting superintendent of Zion National Park, Levi A. Crocker, wrote to Dr. Reed H. Blake at Brigham Young University expressing his desire to have "a professional survey crew provide a sound, defensible measurement of the arch." Blake, a sociologist, had written about the area for a number of publications, and Crocker asked Blake if he might bring together such a professional crew--as a voluntary effort--from personnel at the university.

This request from Supt. Crocker came at the urging of Chief Park Naturalist Victor L. Jackson, who, for a number of years, had been trying to get a survey of the arch made. With Zion National Park's Diamond Jubilee to be celebrated in 1984 (and a contact station being opened on the Kolob Canyon side of the park), Jackson felt a scientific measurement of Kolob Arch was a must.

Following the NPS request, Blake met with W. Don Budge of the civil engineering department and discussed the matter. Dr. Budge reported the best way to get a "sound, defensible measurement" of Kolob Arch was with electronic distance measuring equipment (light beam) mounted on a Zeiss theodolite. This method represents the "state of the art" in surveying.

From the meetings of Blake and Budge, a professional crew

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came together. It consisted of Clyde R. Naylor as chief surveyor. Naylor was then teaching a surveying class at BYU and is both the Utah County (Utah) surveyor and engineer and a member of several professional societies. Selected to assist Naylor were Brad Babcock, a graduate student in civil engineering and president of the BYU chapter of the American Society of Civil Engineers; and Reed Murray and James Williams, both civil engineering students and members of the society.

In the meantime, Harold L. Grafe was named superintendent at Zion National Park. He supported the effort to measure the arch, and pledged two pack horses and a ranger to handle them. He also named Victor Jackson liason for the Park Service, citing Jackson's efforts in publicizing Kolob Arch.

The administration at BYU aided the effort by providing two, 4-wheel drive vehicles. The BYU civil engineering department provided the electronic measuring equipment.

The surveying party met at Lee Pass trailhead on the Kolob Canyon road at noon on July 27, 1983. The party consisted of Blake, Naylor, Jackson, Babcock, Murray, Williams, and Jon Anglin, park ranger who handled the horses; Sandi Sanders, the summer editor of the BYU Daily Universe (who a few weeks later would join the staff of the Color Country Spectrum, a southern Utah daily); Barbara Crownover, a Daily Universe photographer; Haruo Higashimoto,

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a PhD candidate in sociology at BYU (now Dr. Higashimoto of Kwansei Gakuin University in Japan); Blake's son Steven, a junior in high school; and Naylor's wife Fae, his teen-age son Bret, and three younger children.

This group was joined at the arch the next morning by Gary Ferguson, a Colorado writer from Cherry Creek (near Durango), who was in the park doing a story on Zion's Diamond Jubilee for the National Park Review.

Also at the Lee Pass trailhead was J. L. Crawford and his wife Fern. They drove up from St. George to see the group off (but did not make the trek). Crawford is a retired assistant chief park naturalist who served with the NPS at both Bryce Canyon and Zion Canyon.³

After an afternoon of hiking, the party established a base camp at the junction of La Verkin Creek and Crystal Creek, about a half-mile from the arch.

By eight o'clock the next morning (July 28) the party was at the place where Crystal Creek branches into three brooks, and the place at which the arch can first be seen. Except for Blake and Jackson, it was the first time the others had viewed the arch.

³In correspondence with Reed Blake dated April 1, 1977, these observations by Crawford are of interest here. Wrote Crawford: My assignment as a ranger...during the summers of 1948, '49, and '50 was in Zion National Monument, now the Kolob section of Zion National Park. The Kolob Arch was common knowledge among park personnel...and the probability of its being as big or bigger than Rainbow Natural Bridge was batted around,...During my years

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The nature of the terrain and the fact the arch clings high up the wall of the canyon combine to make it necessary to use the process of triangulation to determine the span of the arch.

Accordingly, at this point the survey party was split into two groups. One group consisted of the engineers, Naylor, Babcock, Murray, and Williams. This group--with the surveying equipment on their backs--crawled, roped, pulled, and pushed its way up the north, or right, side of the canyon, and set up a position for triangulation. Then part of the crew crossed over to the south, or left, side of the canyon and set up the prisms and the second position for the process of triangulation.

If done correctly, there is no significant limiting factor in the use of electronic distance measuring equipment. However, one tendency toward error is that in making the triangulation, the light beam is not returned to precisely the same spot each time (quite easily there could be a variance of several inches). To overcome this error, each of ten sightings were made independently by Naylor and Babcock, and in different sequences of the independent angles. When the results were the same for both surveyors, this error was felt to have been eliminated.

in Kolob I took many pictures of the arch from such places as Death Point and the head of Beartrap Canyon. Late in the summer of 1949 I took a shot from below the arch--maybe the first ever taken from that angle....Although it could be seen from one or two points accessible by car, it doesn't appear as free standing until one gets below it. The road into the "Finger Canyons" wasn't built until 1967.

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In the meantime, a second group threaded its way up the south side of the canyon, gradually working west to beneath the arch. This group consisted of Reed and Steven Blake, Bret Naylor, Crown-over, Sanders, Higashimoto, and Ferguson.

Once at the arch, the second group worked along the highest level possible below the arch, establishing the points at which the right (north) and left (south) buttresses stand free of the canyon wall. While the buttresses of the arch are still well above this level, the flat face of the canyon wall makes this identification possible with the naked eye. The use of binoculars further aided this endeavor.

Group two established the two points where the arch stands free--the two points for measuring the arch's span--with no disagreements among its members.

At 11:10 a.m., the two Blakes and Ferguson returned from the arch and met with Jackson, the chief park naturalist, in a grotto in the canyon beneath the arch and discussed their findings. Then the two Blakes worked their way up the north side of the canyon to deliver the two reference points to Clyde Naylor and his crew.

Following the work on the north side, Naylor and his crew (at 1:25 p.m.) crossed over to the south side and took sightings there. In all, the engineers took 10 sightings on each side of the canyon.

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This concluded the work in the canyon.⁴

On returning to Provo, the engineers put their work into a computer. Their findings indicate the span of Kolob Arch is 310 feet, plus or minus 12 inches.

⁴As a matter of historical record, the survey party left the canyon in five groups. Ferguson, the Colorado writer, left the canyon as he came in, alone. He left soon after the conference with Jackson and Blake at the grotto. Later, Jackson left, also hiking out alone. Clyde Naylor and his family left later that same afternoon, after the engineers had completed their work. The two Blakes, Crownover, Sanders, and Higashimoto, after going up La Verkin Creek and exploring Beartrap Canyon, left the base camp at sunset and hiked to Timber Creek where they spent the night. The three remaining engineers stayed that night at the base camp with the equipment, until the two horses and Anglin arrived the next day to pick it up.

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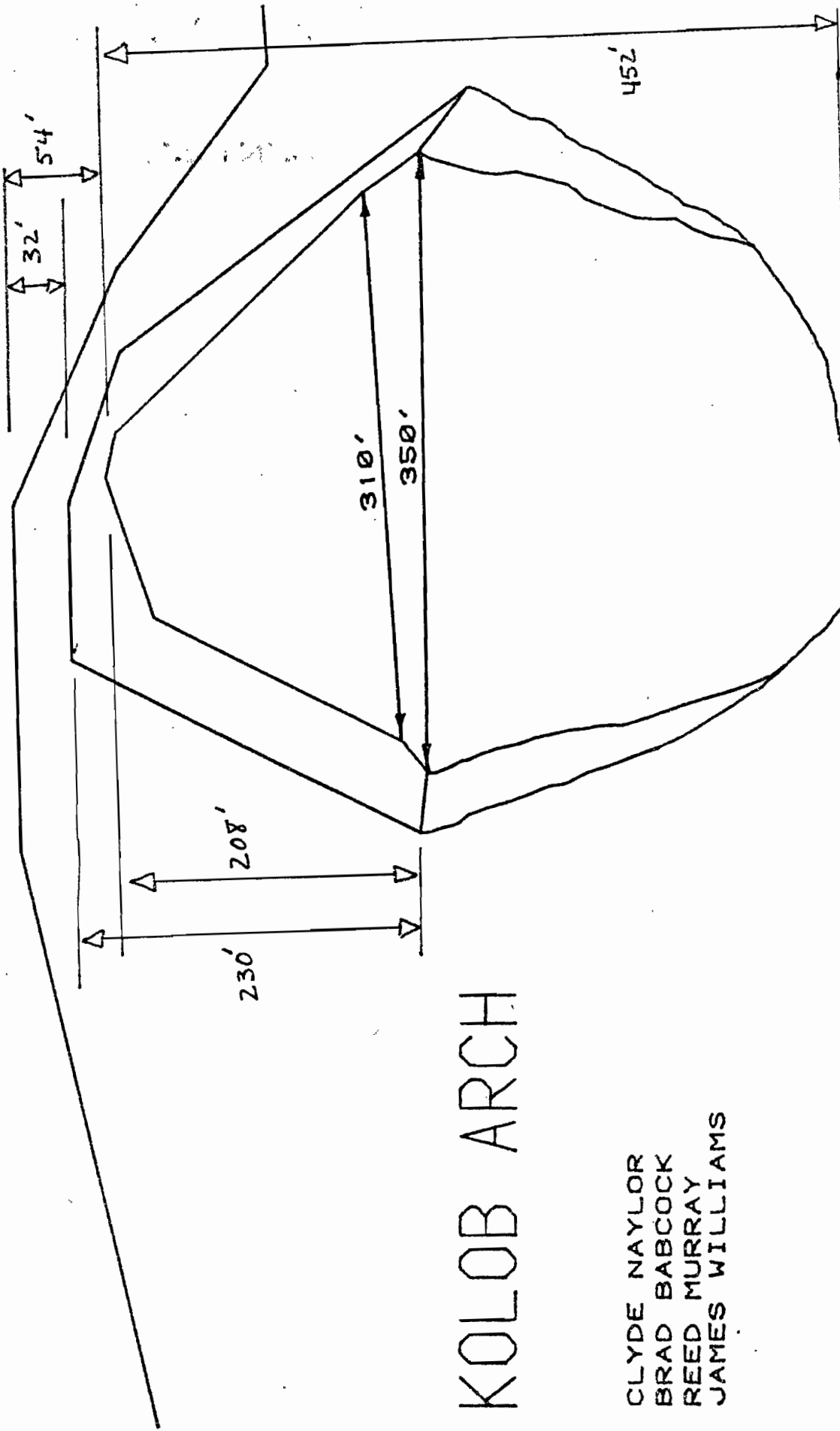
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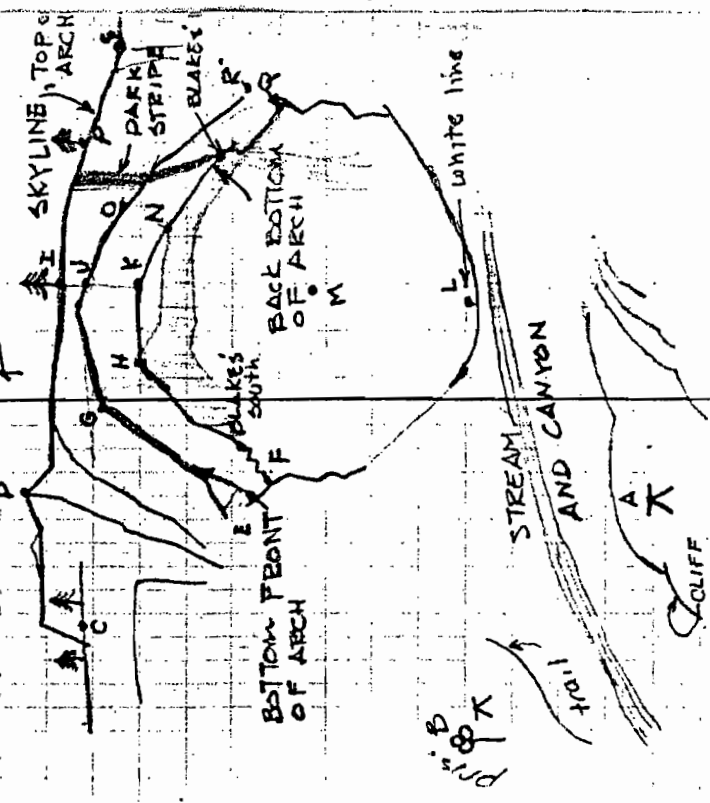
CLYDE NAYLOR
BRAD BABCOCK
REED MURRAY
JAMES WILLIAMS

KOLOB ARCH



SURVEY, ZION'S PARK
 HEAD SURVEYOR: CLYDE NAYLOR
 REED MURRAY
 BRAD BABCOCK
 JAMES WILLIAMS

TEMP. 80° F. (CLEAR)
 DATE: 7/26/83
 HI = 4.855' NOTES
 PRIS. H = 5'



7/28/83
 James Williams

PT.	KOLOB HORIZ. DIST. VERT. ANG.	ARCH HORIZ. ANG.	ARCH VEET ANG.	HORIZ. ANG.
AB	481.44' 92°06'	-	92°07'	-
AC	421.44' 92°05.5'	26°40'	54°39'	26°37'
AD	54°38'	42°21'	54°35'	26°12'
AE	51°02'	42°58'	51°02'	42°18'
AF	60°10'	44°23'	60°10'	42°56'
AG	61°18'	47°18'	61°18'	44°22'
AH	54°31'	48°09'	54°31'	47°16'
AI	56°49'	51°22'	56°50'	48°08'
AJ	53°26'	51°22'	53°26'	51°20'
AK	54°25'	51°22'	54°23'	51°20'
AL	56°49'	51°22'	56°49'	51°20'
AM	69°26'	51°22'	69°26'	51°20'
AN	62°09'	45°12'	62°09'	51°20'
AO	57°12'	52°23'	56°55'	52°23'
AP	56°58'	55°37'	55°17'	55°36'
AQ	55°17'	58°28'	54°18'	58°25'
AR	54°17'	60°07.5'	62°09'	60°05'
AS	62°09'	62°35'	60°34'	62°35'
	60°34.5'	64°51.5'	56°45'	64°48'
	56°45'			

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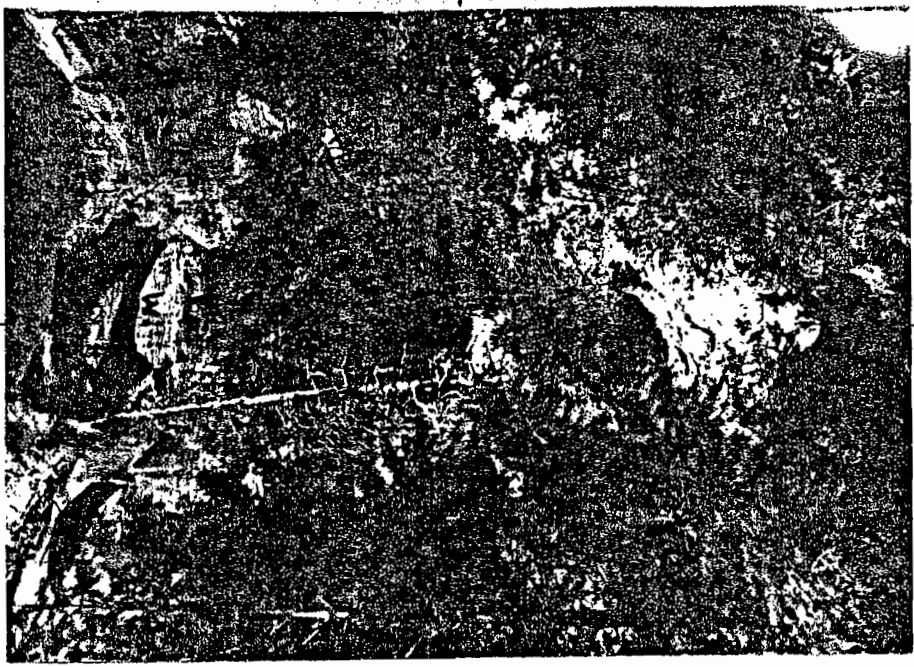
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James Williams
7/28/83

SURVEY CONT. ZION'S PARK



PT	VECT ANG.	KOLOPS HORIZ. ANG.	ARCH
BA	42° 26'	137° 16.5'	42° 26'
BC	42° 13.5'	115° 58'	115° 38'
BD	52° 06.5'	115° 42.5'	115° 44'
BE	53° 49'	115° 10'	115° 00'
BG	47° 11.5'	111° 36'	111° 35'
BH	50° 08'	111° 22'	111° 24'
BI	47° 06.5'	106° 45'	106° 51'
BU	47° 49'	106° 45'	106° 51'
BK	50° 39'	108° 25'	108° 20'
BL	51° 05'	106° 50'	104° 48'
BM	64° 25'	104° 45'	64° 25'
BN	50° 56.5'	107° 16'	(106° 51')
BO	50° 08'	102° 00.5'	107° 14'
BP	49° 36'	98° 02'	102° 00'
BQ	58° 24'	98° 18.5'	98° 01'
BR	56° 58.5'	93° 02'	98° 20'
BS	53° 26'	91° 02'	93° 00'
BLAKE'S No.	53° 24'	113° 54.5'	91° 02'
BLAKE'S No.	57° 05'	79° 51'	

2353.9881	6486.58
726.6625	1674.20
11.	
2327.6340	6463.75
648.5783	1691.50
12.	
2382.1928	6034.16
810.2299	1657.92
13.	
2353.2289	6255.55
724.4133	1676.75
14.	
2350.1670	6460.68
640.8376	1714.88
15.	
2442.6739	6456.23
703.0437	1763.89
16.	
2510.7879	6458.58
729.4643	1809.67
17.	
2527.3490	6284.23
624.2673	1876.61
18.	
2559.7714	6256.66
745.9321	1878.50
19.	
2643.9784	6371.88
727.4612	1926.02
20.	
2232.0211	6295.31
777.5799	1944.19
21.	
2497.6107	6174.88
618.1008	1853.94

FROM POINT