ACCURACY and DECLINATION
Using Panel Activity to Answer Rock Art Questions

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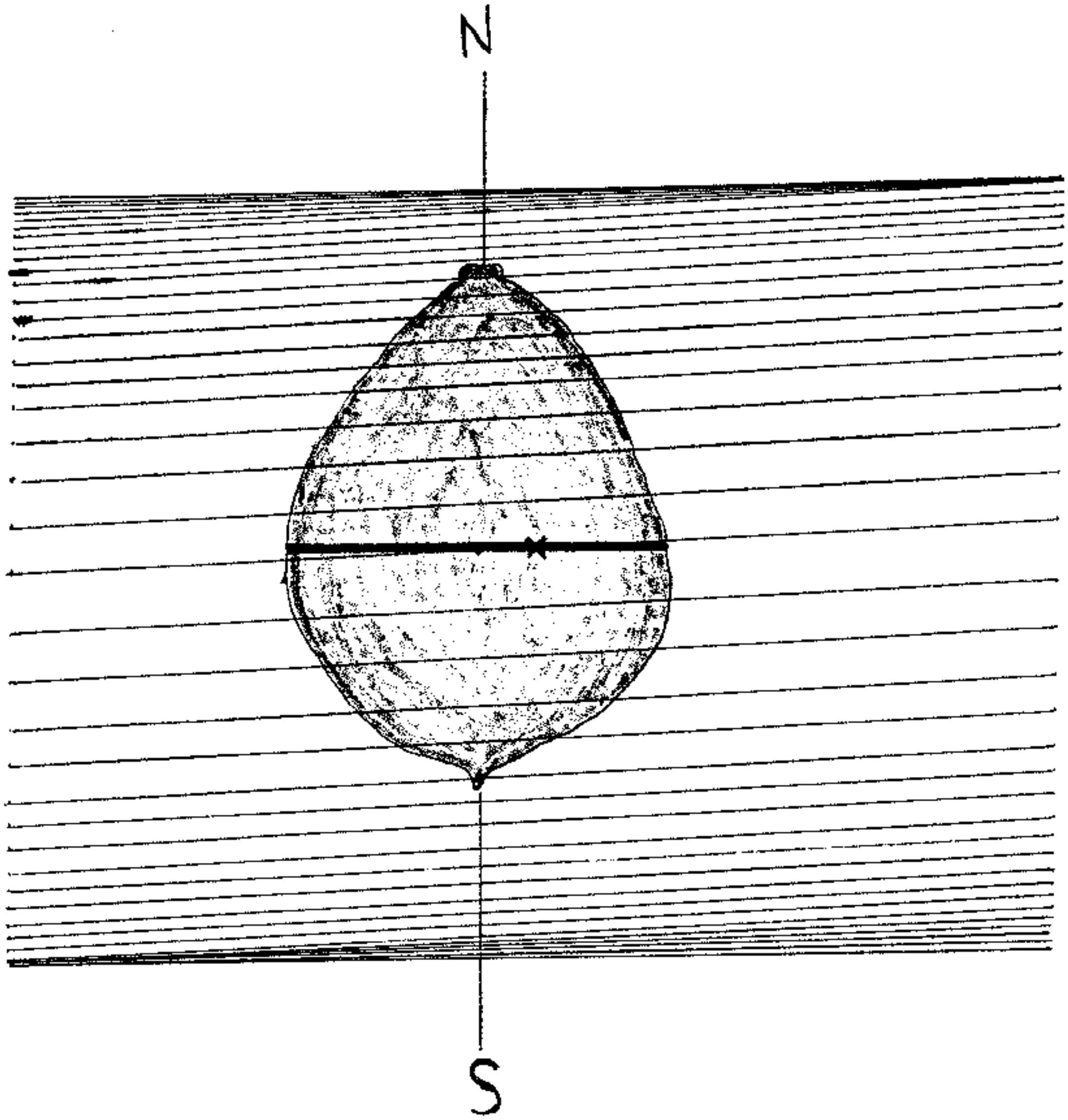
"What are the durable unchanging characteristics that the events of the present share with the past?"
Lewis R. Binford (1981)

I would like to acknowledge the help of Nal Morris and his ever ready computer; and archaeologist James Truesdale who helped with questions, suggestions and volunteer time. My main interest in rock art research continues to lie in developing methods for investigation, tools and techniques which help to answer (and ask) research questions about the nature, purposes, development and interpretation of rock art.

The major factor affecting the changing display of an interactive rock art panel from day to day is the declination of the sun at time of panel function. Declination can be defined as the angular distance north or south of the celestial equator for the center of the sun at a given time (measured along a great circle passing through the celestial poles). Yearly tables of the sun's declination at noon each day for a given time zone are widely available. Changes resulting from the Earth's wobble over the centuries can be determined.

It is easiest to consider the practical effects of declination change with an earth-centered model of the earth-sun system, such as the lemon and the Slinky toy (Figure A). Think of the earth as a lemon suspended in space, north pole up and south pole down, a line painted around the circumference halfway between the poles representing the equator. The day half of the lemon is visible, the night half of the lemon is on the back side. The lemon is centered in a slightly extended Slinky Toy, the coils representing the path of the sun. Near the equator the coils are more open, as the declination changes more quickly at equinox. The time of equinox for the model is the point at which the coil intersects the equatorial line at X. Winter and summer solstices are represented respectively by the south (bottom) and north (top) ends of the Slinky. The coils get closer together as one follows them north or south, just as declination changes per unit of time decrease as the sun moves away from equinox, until



The Lemon and Slinky Model
Figure A

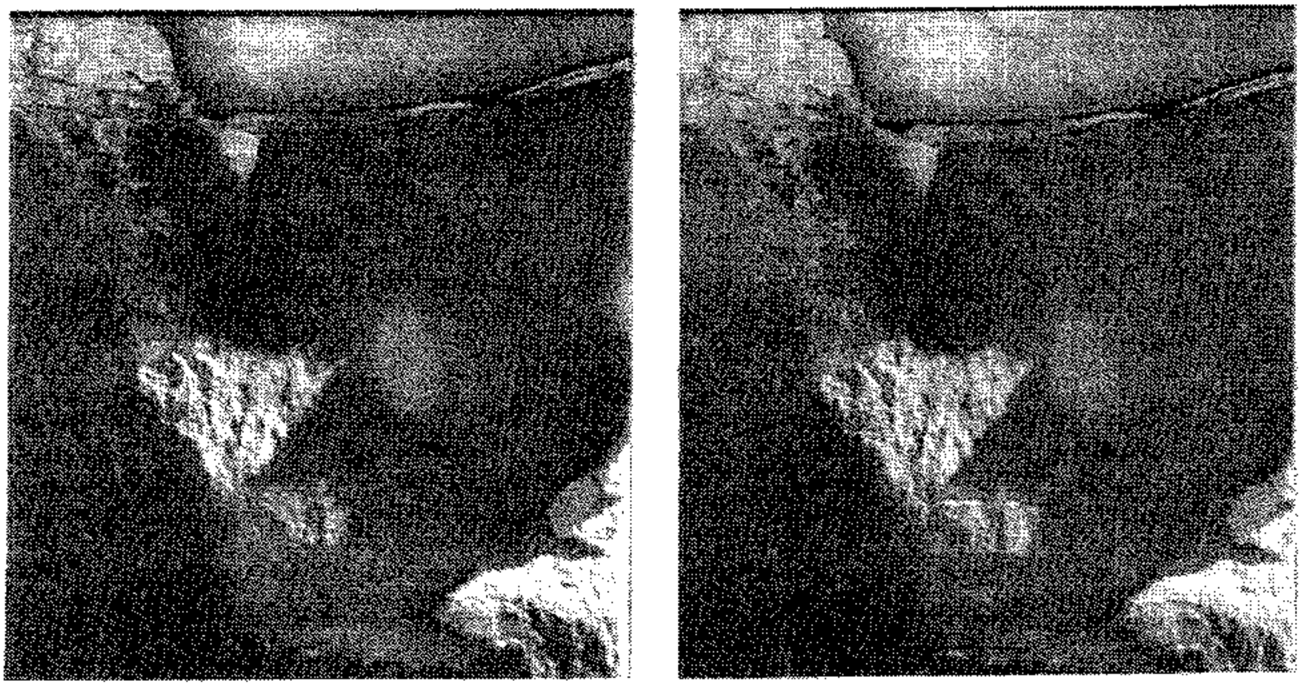
at either solstice the sun holds the same declination for two or three days, represented here by the coils actually touching each other. Between summer solstice and winter solstice the sun travels down the coils the entire length of the Slinky, from north to south. Between winter solstice and summer solstice the coils must be reversed so the sun, while continuing to rotate in the same direction, travels up the coils.

A second factor influencing changes in panel display from day to day is panel accuracy. As discussed in a previous paper on terminology (Johnson, 1990, #1) some "Seasonal" panels, seem designed to display alignments over an extended number of days. Other "Precise" panels seem designed only to achieve an exact alignment on a given day. To use declination and panel accuracy as problem solving tools requires acceptance of the premise that alignments of Precise panels were meant to be exact on a given day and that any variance from exact alignment is due to factors other than design. Thus, any variance must be considered and explained. Plate 1 demonstrates two examples of exact alignment of glyph features with the sun and shadow on key dates. Note that Panel 16 on Plate 1 shows an obvious misalignment with the pecked dot for declination differences of 5 Minutes of Angle, or MOA. It is probable that intermediate declination changes of 2 or 3 MOA could be discerned for this element.

Several panels now being studied (Johnson, research in progress) display recognizable misalignments for less than 3 MOA declination change.

A model winter solstice sunset panel was constructed on a West facing cinder block wall, the gnomon being the corner of a window 1.47 meters southwest of the panel (Plate 2). Relatively uniform sunset shadow position changes of approximately 1 mm per MOA were obtained (Figure B) except where an anomaly (a down slope on the other wise relatively flat horizon altered the situation between the 6th and 14th of December. Note that sunset position for a horizontal shadow line changed very little during the entire experiment. Construction of model panels for various situations could aid in the understanding of actual panels. Work needs to be done in this area. Displacement of the vertical shadow line caused by the 5 MOA declination change between the 17th and 21st of December is very obvious, and this panel could easily detect differences of 2 1/2 MOA. Increasing gnomon distance is increasing the angle of the panel surface to the sun would increase the amount of change in shadow position per MOA. Natural gnomons up to nineteen meters from panels have been identified, and panels which interact at extreme angles to the sun position are common.

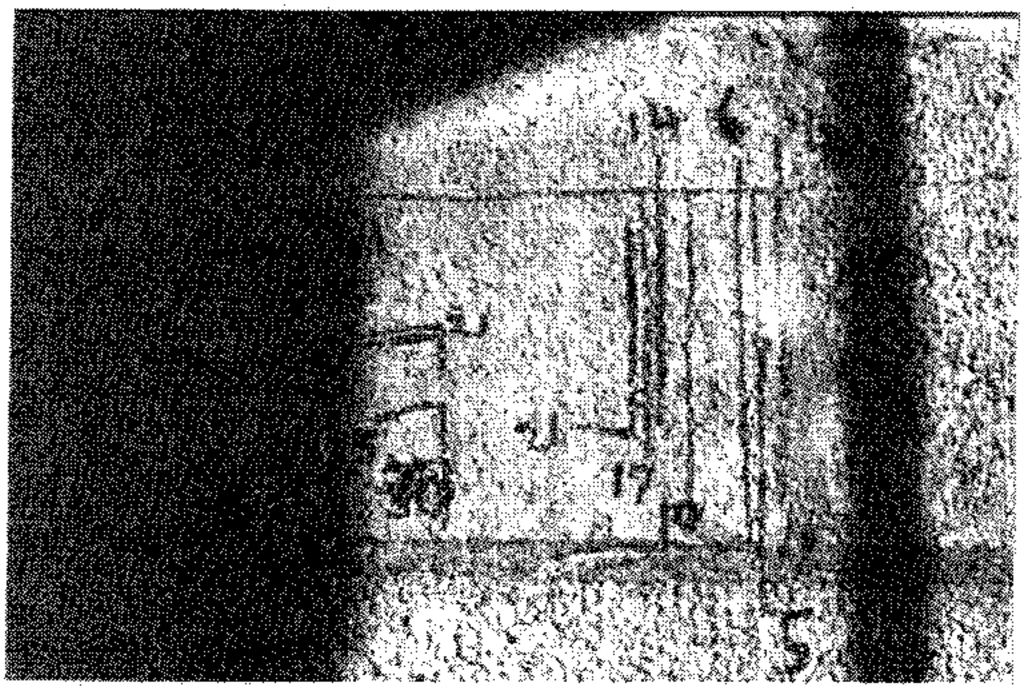
A welder's lens was used to observe the portion of the sun disc remaining above the horizon relative to shadow brightness and position. The findings agreed with observations of sunrise



Panel #3: Tip of sun arrow approaches (L) the travels along (R) pecked line.

Panel #16: Peak of interaction at (L) 23°21' and (R) 23°26'

Accuracy and Declination, Plate 1



A working model sunset spot winter solstice panel constructed on a cinder block wall. The panel faces west and the gnomon is a window frame 1.47 meters southwest of the panel.

Plate 2

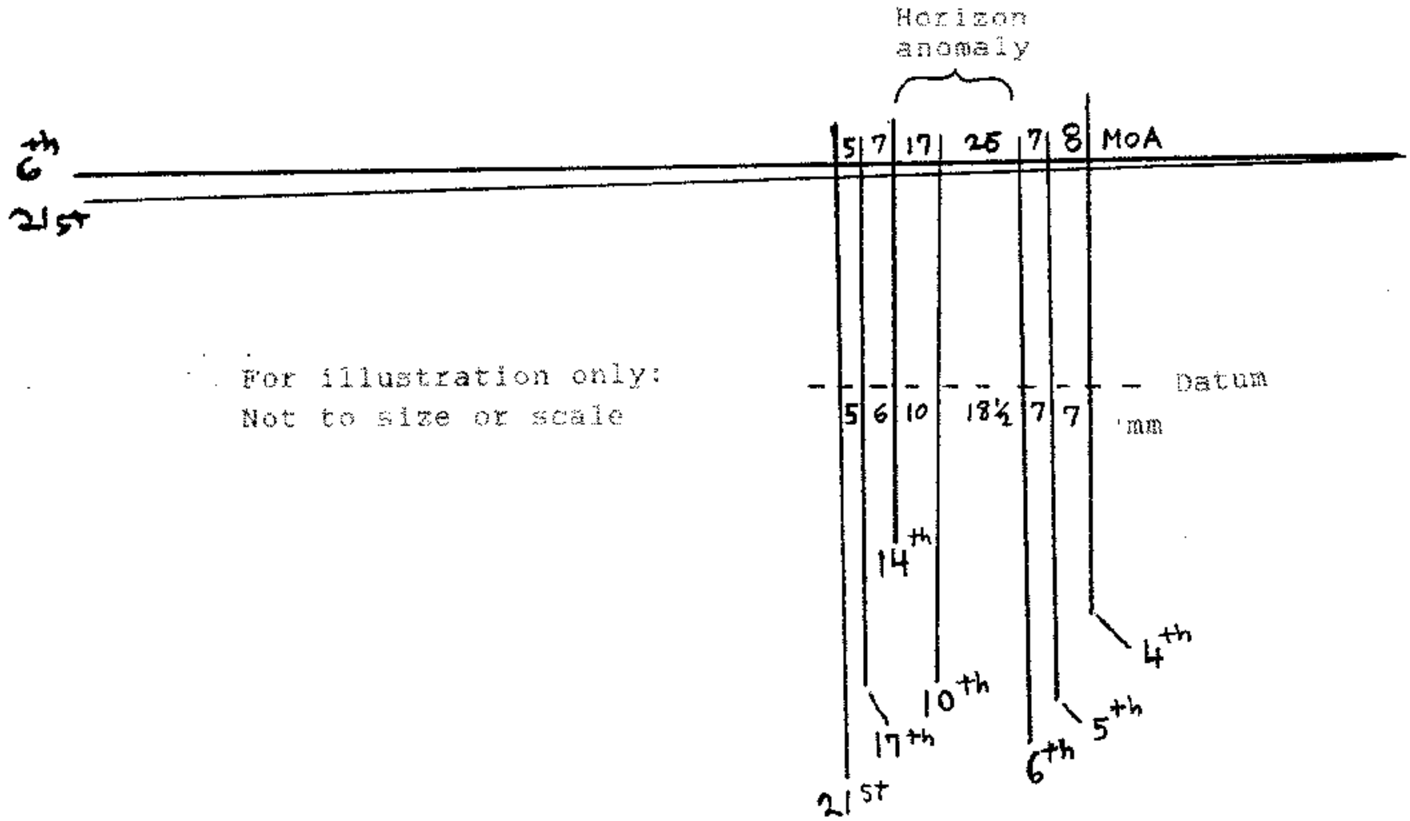
at various actual panels. From full disc to nearly one half disc exposed there is very little relative difference in brightness and no discernable difference in shadow position. From one half to one third disc exposed, the sun-shadow line fades rapidly. When less than one third of the disc is exposed the line cannot be identified. This would seem to indicate that interactive panels rely on the center line of the sun disc as the light which creates the utilized shadow.

The "reading accuracy" potential of any panel must be examined and taken into account when working with accuracy and declination, generally as a "tolerance" plus or minus for any calculations.

To use declination and panel accuracy as tools, there are certain minimum requirements:

1. Precise panels must be selected, and the reading accuracy of each panel researched.
2. A table of daily noon declinations for a given time zone, adjusted to the time zone for the panel site. Each year the Western Edition of The Old Farmer's Almanac by Robert B. Thomas contains daily declinations for noon Pacific Standard Time rounded to the nearest MOA. For dates other than solstices this declination must be adjusted to reflect time zone at panel site. In Utah for instance, at equinox the PST declination must be adjusted by .97 MOA to reflect the noon Mountain Standard Time declination. This adjustment may be plus or minus, depending on which equinox is being considered and whether the declination is North or South at noon. For crossquarter dates, the MST adjustment would be .71 MOA, plus or minus depending on the particular crossquarter being calculated.
3. A way of recording the changing shadow pattern on the panel on several selected days, and a way to measure changes in precise alignments within the pattern. Caution! No method that involves touching or marking the panel is acceptable. Theoretically, video tapes from a photo station could be fed into a computer, and a program designed to display tiny variations in the display from day to day, even to project pattern changes into the future. This is well within the range of present technology, lacking only money and time, and would yield very accurate solution for some panels.

Alternately, a low tech approach using slides, sketches, and plastic overlays is useful enough to yield some answers. Selection of panels, especially for this rough technique, is critical. Required are a sun-shadow shape that has the definition or sharpness of feature to allow slight misalignments between the shadow shape and the glyph clearly differentiated, an unambiguous direction of motion for the shadow shape as it interacts with a glyph. Preferred shapes for accuracy would be



December 4 through December 21, 1990

Date	Declination	Change in MOA	Line Displacement in mm	mm/MOA
12/4	22° 16'	-	-	-
12/5	22° 24'	8'	7	.88
12/6	22° 31'	7'	7	1.0
12/10	22° 57'	26'	18.5	.71
12/14	23° 14'	17'	10	.59
12/17	23° 21'	7'	6	.86
12/21	23° 26'	5'	5	1.0

Figure B

the sun and shadow arrows, sun dagger, sun cup, or sun and shadow nubbins; the sun arrow is best because the fine point, usually found to be interacting with the glyph, clearly defines an exact point on the panel. The preferred glyph element for accuracy would be a single pecked dot with which the sun arrow originally aligned at culmination of the interaction. The preferred motion of the sun arrow during the interaction would again be unambiguous. A "spot" panel of which the arrow-dot alignment occurred at sunrise or sunset for the site could be used. A vertical sun arrow cast by a gnomon above the panel (superior gnomon), at the tip of which moved horizontally across the dot at midday would be acceptable. A vertical sun arrow cast by a superior gnomon on (for example) an east facing panel, which moved vertically through the glyph dot, with misalignments due to declination change evident as displacement to the left or right of the day, would be useful. The makers of these panels were apparently concerned with achieving exact alignments on certain days, rather than designing panels which would clearly define slight misalignments. Although the difference between the two approaches might not be immediately obvious, it is critical to understanding and working with interactive panels. Two years worth of accumulated but so far unpublished data from the area of Dinosaur National Monument (Johnson, research in progress) indicates nearly all of the panels rely on natural gnomons casting shadow shapes which were utilized by the construction of the glyph elements aligned with the sun-shadow shapes as they moved across the panel on a key date. Thus, no control of what the shadows did before or after the key date was possible.

To put it another way, panels appear to have been selected for use because they had interesting shadow shapes moving across them on dates important to the makers. The exact appearance of the panel interaction on days before and after the key event was apparently not important. Further, the makers apparently deemed it important in many cases for the same panel to interact on many or all of the key dates so far identified (solstices, equinoxes, crossquarters) and thereby often increased the ambiguity of particular interactions on some cases by "fudging" the width of lines of the size of pecked dots to accommodate slightly different interactions on two or more key dates. Thus while misalignments with the glyphs might be visible to the panel observer for the very small declination changes, the direction and amount of those misalignments seldom proceed in directions easily measurable as incremental displacement along a straight line.

To be susceptible to confident analysis, a panel ideally would combine a clearly defined sharply pointed sun arrow, a single pecked dot as a glyph element, a "spot" alignment at sunrise or sunset, and a gnomon-panel relationship that resulted in clearly visible, easily measurable incremental misalignments for each MOA of declination change. Very few panels are likely to even approach this ideal.

With these facts in mind, let us examine the potential use of accuracy and declination studies as a tool in three situations: as an objective, non-destructive dating device for solstice panels; as a tool to help us research the prehistoric understanding of equinoxes; and as a tool to help confirm, or alternately reject, other hypotheses in rock art such as the so-called AS 1054 Supernova panels.

Solstice

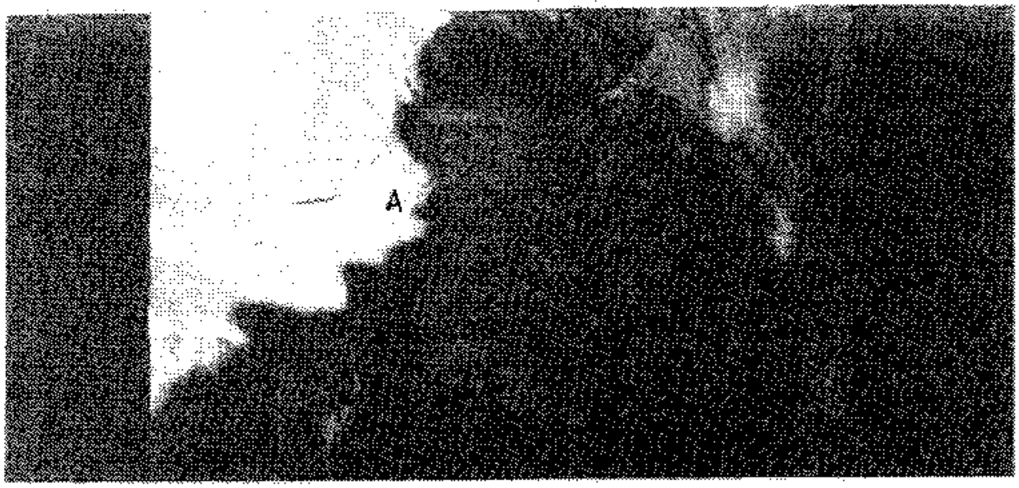
Since the path of the sun occupies essentially the same declination for three or more days at solstice, the effect of hourly or daily declination changes can be ignored for this period. For panels still recognizably interactive, geologic effects such as earth movement due to earthquakes can also probably be ignored, although the possibility dictates that a site with multiple related precise solstice panels for which calculations could be averaged would yield the most accurate result.

Research (Johnson, 1989-1991; research in progress) has identified a number of precise solstice panels at one site, at least eight of which today do not reach an exact alignment with the target element at solstice. For the summer solstice interactions, it appears that if the sun went a little farther north the alignment would be exact.

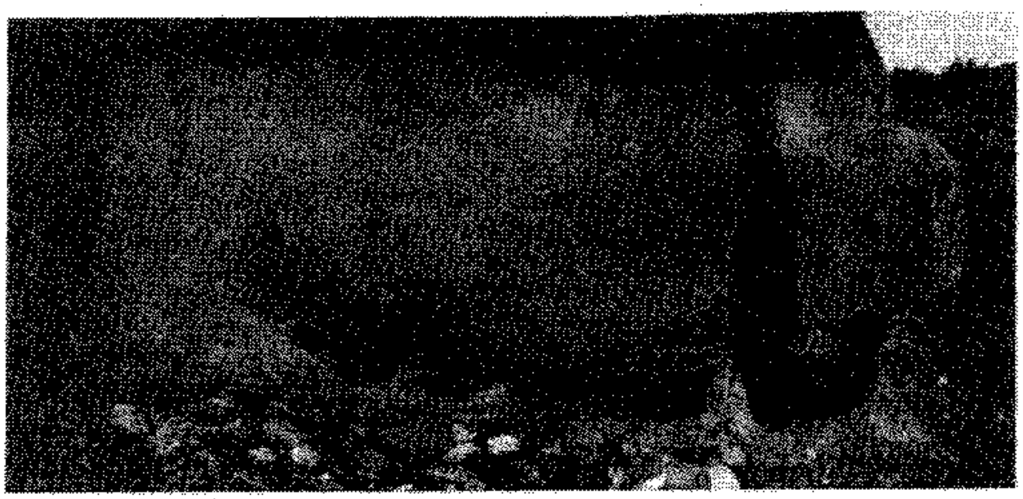
For the winter solstice alignments, it appears that if the sun went a little more south the alignments would be exact. Plate 3 shows several examples of these interactions which today don't "go far enough." This is precisely as it should be, given precise panels constructed centuries before the present. The phenomenon of the earth wobbling around its north-south axis, sometimes called the degradation of the obliquity or the precession of the equinoxes, has had the effect of changing the range of declination for the sun over a year period. The result is that today the sun does not "go" quite as far north and south as it did several thousand years ago. To alter our lemon and Slinky model to represent the situation 1000 years ago, we would have to stretch it slightly at both ends, leaving the middle (equinox) where it is and distributing the change throughout the coils. Figure C shows the changes in Declination for selected intervals in the last two thousand years.

Figure C

KEY DATE	AD 2000	AD 1500	AD 1000	AD 500	AD 1
Summer Solstice	23° 26'N	23° 30'N	23° 34'N	23° 38'N	23° 42'N
Equinox	00° 00'	00° 00'	00° 00'	00° 00'	00° 00'
Winter Solstice	23° 26'S	23° 30'S	23° 34'S	23 38'S	23° 42'S



Panel #3: Misalignment of sun line at "A" at peak of winter solstice interaction.

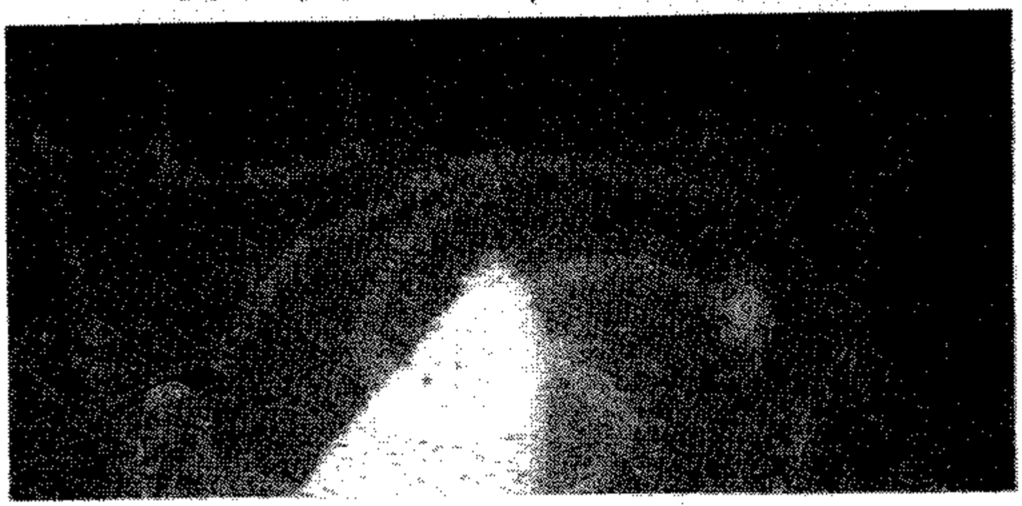


Panel #20: Misalignment of sun arrow at "A" at peak of summer solstice interaction.

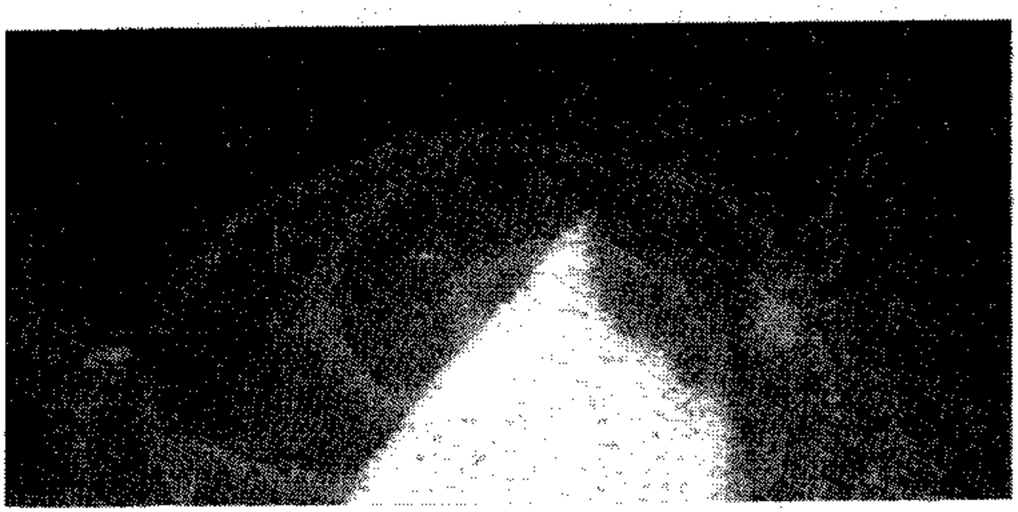
Panel #21: Interior of pecked element not quite fully lit at "A" at peak of summer solstice interaction.

Plate 3

Panel #16: June 15, 1991   10:20 AM



Panel #16: June 15, 1991   10:22 AM



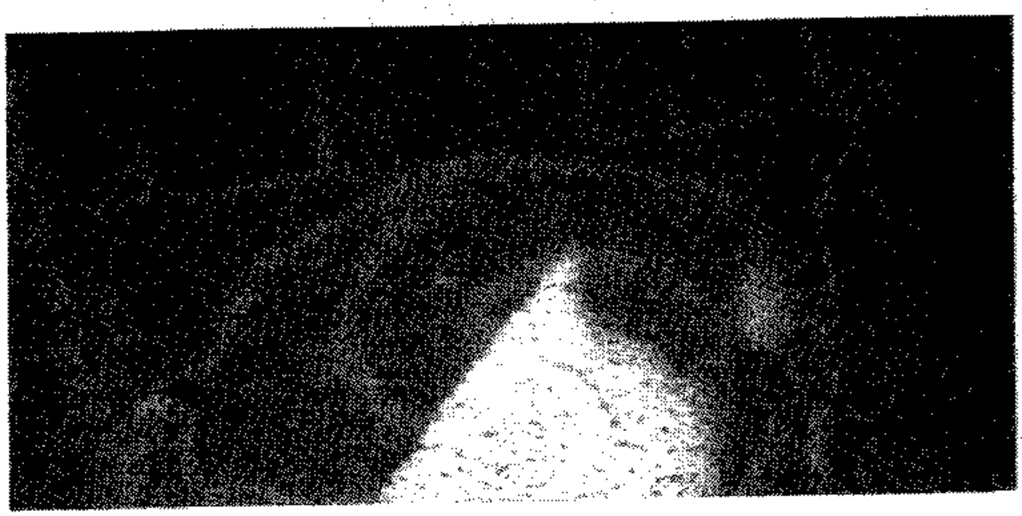
Panel #16: June 15, 1991   10:32 AM

Declination, $23^{\circ}18'$. Summer solstice minus 8 MOA.

Plate 4

Panel #16: June 16, 1991   10:21 AM

Panel #16: June 16, 1991   10:24 AM



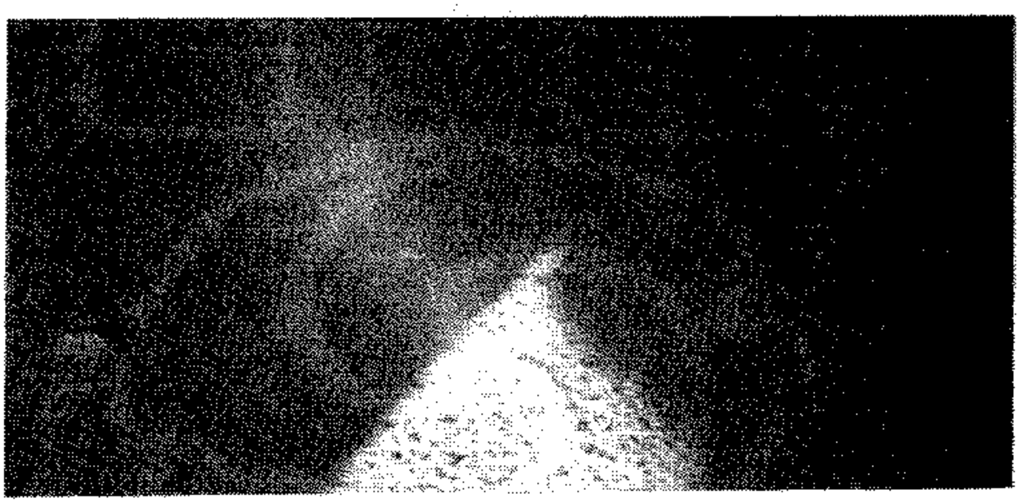
Panel #16: June 16, 1991   10:31 AM

Declination, 23° 21'. Summer solstice minus 5 MOA.

Plate 5

Panel #16: June 21, 1991   10:20 AM

Panel #16: June 21, 1991   10:21 AM



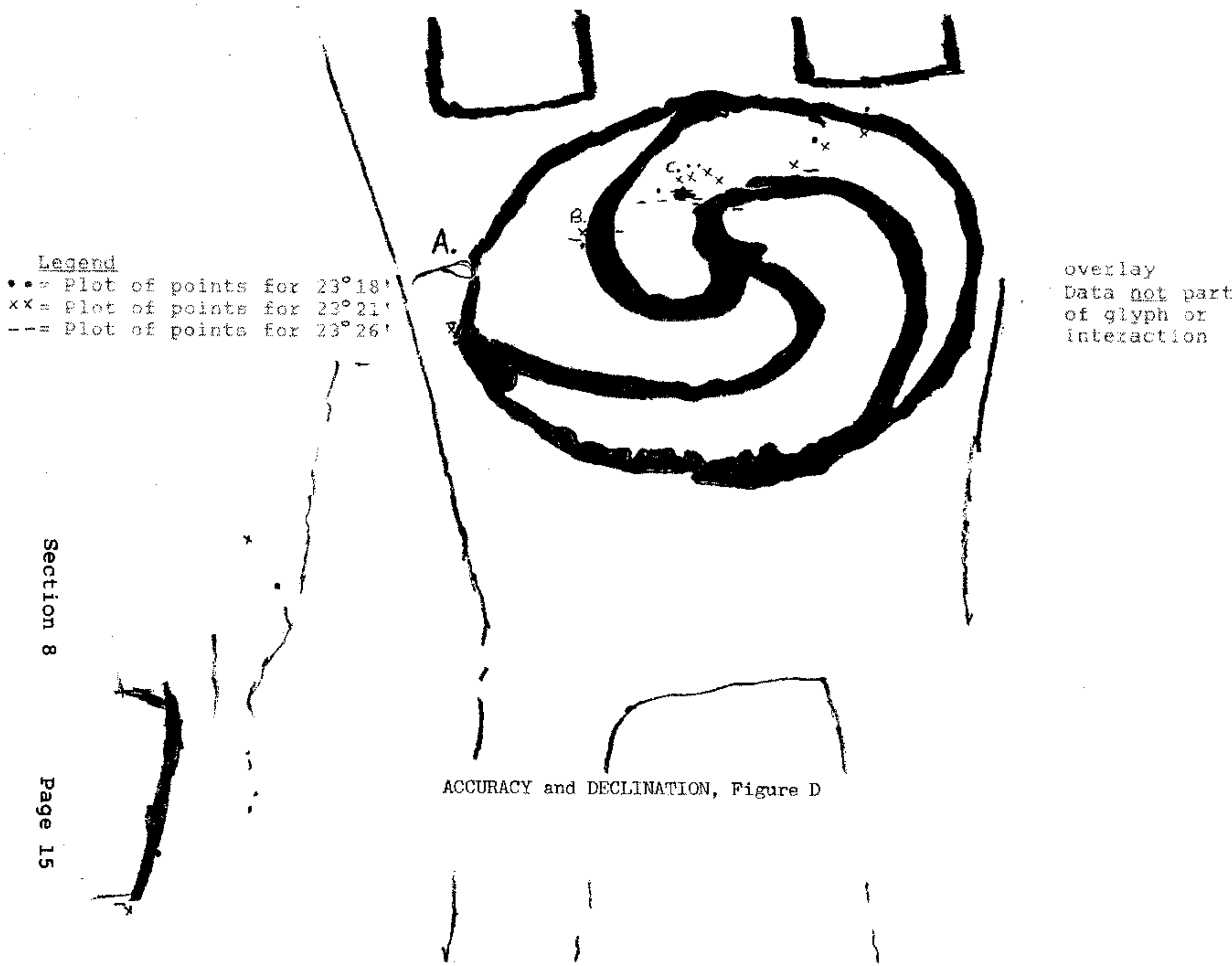
Panel #16: June 21, 1991   10:28 AM

Declination, 23° 26'. Summer Solstice.
Plate 6

The change amounts to about 8 MOA per 1000 years for solstices. For comparison, 8 MOA is equivalent to nearly a week of daily declination changes near the time of solstice today. In 1991, the declination changed 8 MOA between noon on 15 June and noon on 21 June. An observer who could detect unambiguous changes in shadow alignments on a precise panel during the week of 15-21 June could project those changes by an equal amount past the 21 June positions to estimate what the alignment would have looked like 1000 years BP. Thus, observing and recording panel alignments at selected intervals of days (declinations) before a solstice should allow us to do a relatively simple (and relatively rough) projection of an equivalent amount past the present solstice alignment to examine the likely alignment at any date in the past. Reading accuracy will have to be considered of course, as a tolerance for any figure projected as the date of most exact alignment. A panel on which a change of 2 MOA declination was necessary for a detectable change in alignment of the critical element would require any dates obtained to be assigned a tolerance of 250 years. In addition, some fudge factor to allow for the roughness of the method of projecting change would have to be entered. Even with its built-in inaccuracies, this method would suffice to comparatively date interactive panels such as Barrier, Glen Canyon Style 5 and Fremont.

As discussed earlier, more sophisticated methods of recording and analyzing interactions could improve the accuracy of this technique for selected panels. Radiocarbon dating could be utilized with little damage to the panels.

To test the declination dating theory, I selected a panel attributed to the Uintah Fremont, now described as having occupied northeastern Utah between AD 400 and AD 1100 (Truesdale, 1990). I have designated this panel #16. Although not an ideal panel for this method because of a complicated interactive pattern, a relatively poorly preserved panel surface, and a difficult position to photograph. The panel did have the advantage that a clear change in alignment with one pecked element was obvious for quite small changes in declination. Further the interactive shape was a sharply pointed sun arrow, and the small pecked element was located so that the apex of the sun arrow approached it from below, then changed direction to move along the element to the right of the day of summer solstice. Days selected for observations were June 15th 16th, and 21st (solstice) 1991, for declinations of 23 18', 23 21' and 23 26' respectively. In other words, observations were made at a declination 8 MOA south of solstice declination, 5 MOA south of solstice declination, and at solstice declination. Plates 4, 5 and 6 show selected slides from the sequences on these three days. Observations consisted of a series of slide photos taken of the interaction of each of the three days. Photography was



ACCURACY and DECLINATION, Figure D

biased toward interactions with the shield area, where the most accuracy was expected. Although no formal photo station was set up, an effort was made to photograph the shield area on each of the days with the same lens setting and from the same position on the trail below the panel. One of the slides was then projected onto a piece of paper and a sketch made. The series of slides from each day was then projects onto the sketch, the angle and distance of the projector adjusted to obtain the best match of slide with sketch, and a mark made on the sketch to identify the position for the point of the sun arrow. The point only was graphed, interactions for other portions of the sun arrow were not plotted (Figure D). Each point for solstice minus 8 MOA was designated by a dot (.). Points for solstice minus 5 MOA were plotted with an "x". The day of solstice points were plotted with a dash (-). Referring back to Figure C, one can see that 8 MOA is the amount of displacement to be expected due to declination changes between AD 1000 and today, and 5 MOA is the amount of displacement which has occurred between AD 1400 and today. It must be remembered that since the sun does not go as far north today as it did in the past, we are recording declinations displayed to the <u>south</u> of solstice position, and must project these changes <u>past solstice</u> to get a picture of what the interaction looked like at a selected time in the past. Since we suspect that this panel was created about 1000 years ago, a displacement of * MOA was purposely chosen, and a displacement of 5 MOA (similar to the amount of displacement for AD 1400) was selected to give a more complete picture of how the plot of points changed with declination, so that our projection might be more accurate.

The plot of points for each day on a plastic overlay (represented by Figure E) was then connected where data was deemed sufficient by a line, A dashed line (-) connected the minus 8 MOA points, a solid black line the minus 5 MOA points, and a solid red line the points for the present day solstice interaction. It can be seen that the direction and amount of interaction shift for a given declination change is not consistent. This may be the result of a changed "angle of attack" for the sun at different declinations, or an inadequacy of the recording technique (discussed later). It was decided that the critical points for examination were within the shield at A, B and C where the sun arrow has relatively consistent "peaks" or changes of direction.

Two types of projection were then attempted, each by some variant of moving the solid, then the dashed line down to coincide with the plot of points for the interaction today. This displaces the red line downward to reflect the sun arrow position cast by the gnomon, a small notch and crack in a ledge superior to the panel, the direction which would have resulted from a more northward declination in the past. The first projection was made

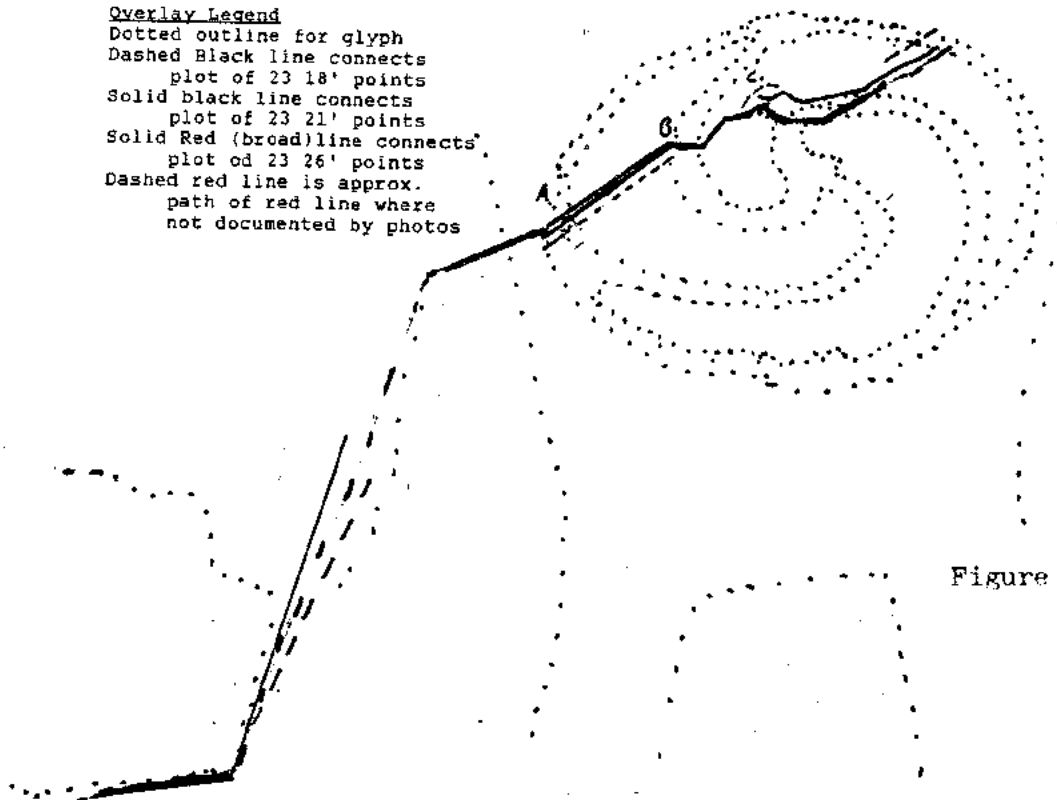


Figure E

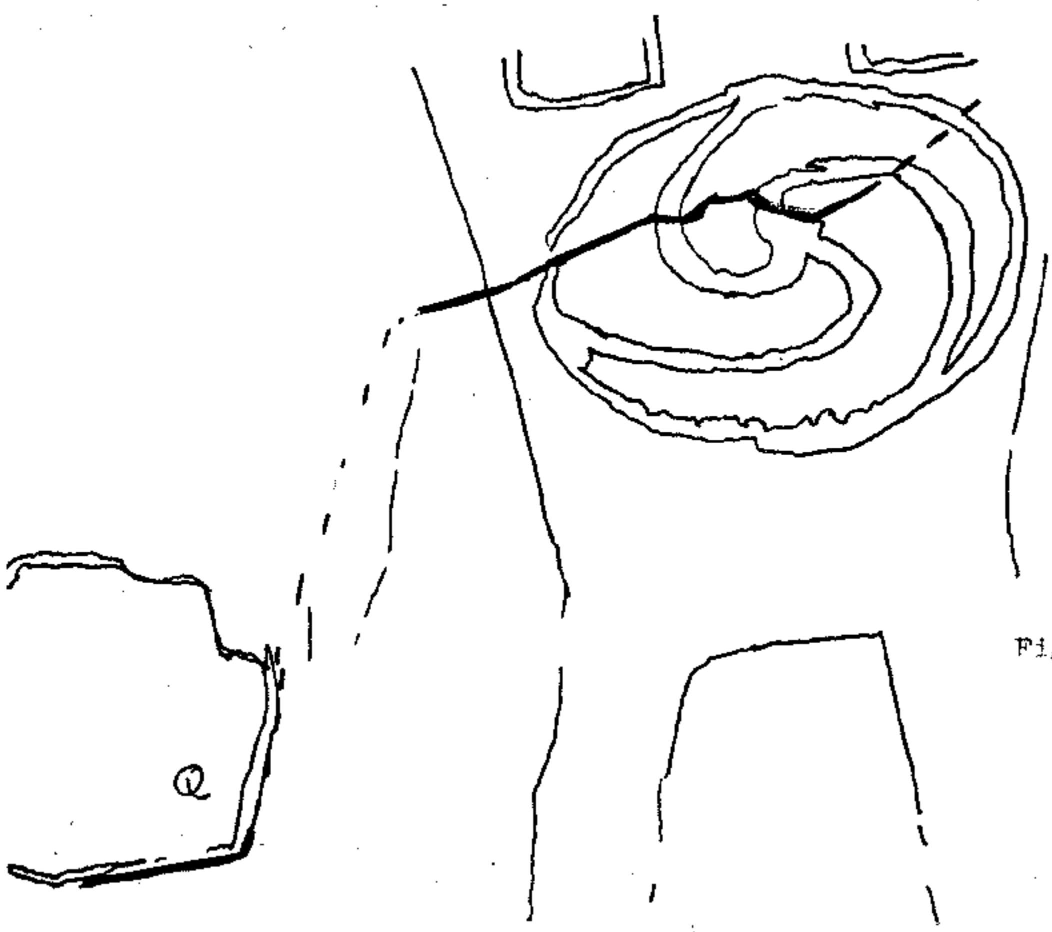


Figure F

by moving the overlay nearly straight downward, an extremely simplistic interpretation. The second projection was made by moving the overlay downward and also applying rotation in the direction of pattern changes for the three lines relative to each other, which should result in a more accurate interpretation. The resultant projected alignment at AD 1000 for the latter method is illustrated in Figure F. The alignment projected for AD 1400 and a projected alignment for AD 500 accomplished by further projecting the displacement and rotation are not illustrated. The alignment for AD 1400 was poor and judged non-significant. The alignment for AD 500 was fair (about as good as today's), but the alignment for AD 1500 (Figure F) was very good; better than today's. It also coincided with glyph asymmetries of the type previously found (Johnson, 1990) to be important indicators for interactive alignments. This suggests that the panel was constructed for the solstice alignment of AD 1000 plus or minus perhaps 200 years, not surprising in light of the fact that we "know" this panel was built about that time. The AD 1000 projection did not align with the small pecked element at C. This too is not surprising, in view of the fact that it does align precisely today, and the fact that careful examination shows considerably less repatination for this element. The pecked mark at C was probably constructed within the last 150 years, perhaps as "glyph maintenance" by Utes.

As a first attempt at dating panels by declination changes, this effort demonstrates both the possibilities and the problems of the technique. One problem which becomes apparent when attempting to plot points on extreme telephoto views of a panel is that these panels were designed to display alignments to the unaided human eye. When viewed closely the sharp distinction between sun and shadow becomes blurred. The focal lengths nearer fifty millimeter may be more effective in viewing this work. Another problem is deciding when to take each photo. A "times" approach, taking photos at set times, is ineffective because the time of a given point in an interaction varies according to declination and other factors. Photos taken at key interactions with glyph elements are less than perfect because we are seeking changes in a pattern, and "fudging" the pattern changes to specific alignment points biases the projection. A variation of such a fudging technique resulted in the alignment at Q on Figure F, which does not follow for any reasonable displacement of the overlay at points within the shield. This problem can probably only be effectively rectified by using Realtime video tapes of the entire interaction for this panel, and computer modeling the direction and rate of change for every point along the interaction when making a projection. Another solution would be to select panels which are less ambiguous as to direction and rate of change for a key alignment, and to use only a small portion of the alignment such as point C in Figure E for the projections. If a video tape is used, experience indicates that a camera of the new "high resolution" variety will need to be used to achieve acceptable results.

One test for the accuracy of our result on Panel 16 would be to adjust the interactive line to project an 8 MOA further south declination, then photograph a plot of points for June 12, 1992 and compare the two lines for accurate match. This test is scheduled.

My conclusion is that this method has potential to date selected Precise solstice panels with acceptable accuracy to answer many interesting questions, and without impacting the panels in any way. As shown above, the method may also help separate vandalism, glyph maintenance, or superimposed glyphs as to likely time of placement on panel. Glyph maintenance (page 7) may be explainable then as an attempt to recapture an alignment which has decayed due to declination change or other factors. At least one other panel at this research site displays the symptoms for this definition of glyph maintenance: a difference in relative repatination and a closer approach to present day interactions than for the "older", more repatinated portion of the glyph. For dating purposes, using the technique for multiple panels attributed to the same occupation at a site and averaging the results would probably yield more accurate dates. High resolution videotaping and computer modeling are probably needed to achieve dating accuracy approaching that of radiocarbon dating techniques.

EQUINOX

The declination situation at equinox is far different than that at solstice. As solstice approached declination changes became smaller and smaller until for a few days at solstice the declination remained effectively the same. Research problems at solstice are in observing very small increments of change in the interaction of succeeding says. As equinox approaches, the rate of declination change per day or hour becomes larger and larger. On the day of equinox, the declination chance in one hour is equal to the declination change in four days at solstice. To put it another way, the amount the sun moves to the north during the 24 hours on the day of Vernal Equinox is equal to the amount it moves north in the eleven days after Winter Solstice. The problem for the researcher is not in identifying the effects of small declination changes, but in dealing with too much potential declination change on a given equinox. To see why this is a problem we must examine definitions of equinox.

Our modern astronomical definition of equinox is based on the exact moment Greenwich Time the center of the sun crosses the celestial equator. The day of equinox is defined as the twenty-four hours from midnight to midnight, during which the moment of equinox occurs.

EQUINOX PANEL DECLINATION TABLE

Equinox: 0° ___'

	Midnight	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	15N	16N	17N	18N	19N	20N	21N	22N	23N	24N	Midnight	
	1	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	15N	16N	17N	18N	19N	20N	21N	22N	23N	11	
A	2	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	15N	16N	17N	18N	19N	20N	21N	22N	10	
U	3	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	15N	16N	17N	18N	19N	20N	21N	9	
T	4	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	15N	16N	17N	18N	19N	20N	8	
U	5	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	15N	16N	17N	18N	19N	7	
M	AM 6	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	15N	16N	17N	18N	6 PM	
N	7	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	15N	16N	17N	5	
	8	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	15N	16N	4	
E	9	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	15N	3	
Q	10	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	14N	2	
	11	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	13N	1	
	Noon 12	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	12N	12 Noon	
	1	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	11N	11	
	2	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	10N	10	V
	3	15S	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	9N	9	E
	4	16S	15S	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	8N	8	R
	5	17S	16S	15S	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	7N	7	N
	PM 6	18S	17S	16S	15S	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	6N	6 AM	A
	7	19S	18S	17S	16S	15S	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	5N	5	L
	8	20S	19S	18S	17S	16S	15S	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	4N	4	
	9	21S	20S	19S	18S	17S	16S	15S	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	3N	3	E
	10	22S	21S	20S	19S	18S	17S	16S	15S	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	2N	2	Q
	11	23S	22S	21S	20S	19S	18S	17S	16S	15S	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	1N	1	
	Midnight	24S	23S	22S	21S	20S	19S	18S	17S	16S	15S	14S	13S	12S	11S	10S	9S	8S	7S	6S	5S	4S	3S	2S	1S	0	Midnight	

Note figures are in Minutes Of Angle (MOA) declination North (N) or South (S).
Autumn Equinox: Use the left hand timeline, reading down the table.
Vernal Equinox: Use the right hand timeline, reading up the table.

Figure G

Prehistoric peoples could not have used this definition. Peoples living on or near the equator could have, and apparently did in some cases define equinox as the day the sun rose directly in the east and set directly in the west, or the day the sun was vertically overhead at midday and a vertical stick or pyramid cast no shadow.

None of the above definitions would have been useable by a prehistoric people such as the Uintah Fremont, living in deep-cut canyons and mountainous terrain at 40 degrees north latitude. Jesse Warner, Nal Morris, Gerald Dean, Clifford Rayl and others have offered suggestions for determining local solar noon, a true east-west line, a true north-south line, true east or west, and the changing shape of the line cast by a gnomon as equinox approaches. Although all these ideas have merit and may lead to other useful insights, none of them quite convinces me that they would unambiguously identify the day of equinox for all equinoxes for our Fremont observer. This them is a worthy question for research. In what way did the Fremont define equinox? Or to phrase if differently, how much had the Fremont been able to discover about the event we call equinox, and how did they discover it?

Today, the day of equinox for a given location on the planet is defined as the twenty-four hours, from midnight to midnight local time, during which the moment of equinox occurs.

The moment of equinox for the same location is defined as the moment local time that the center of the sun crosses the celestial equator. Because of the one-quarter day mismatch between our days and the solar year, the moment of equinox for any given location varies from equinox to equinox. The moment of equinox can occur any time from one minute after midnight in the morning of the day of equinox to one minute before midnight on the evening of the day of equinox. Since the declination of the sun at equinox is changing to north or south by one MOA (1') per hour on the day of equinox, and since the sun may start the day of equinox in the south going north or south, a large range of possible declinations exist for the sun at any given hour on the day of equinox. Figure G (Equinox Panel Declination Table) roughly identifies all the possible declinations of the sun at a given hour of the day for all possible equinoxes. It can be seen that the sun can begin the day of equinox nearly 24' south or nearly 24' north of the celestial equator, or at the celestial equator going either north or south. Even after eliminating from consideration the declination changes during hours of darkness (during which solar panels won't function) it is apparent that for a given panel functioning at sunrise, the declination of the sin for a given equinox could be anywhere between 18' north and 18' south! This is a range of 36 MOA or more than half a degree! The problem for the panel builder becomes one not of displaying a precise alignment, but in which equinox to display a precise

EQUINOX DECLINATION RANGE & CHANGE OVER DAYLIGHT HOURS

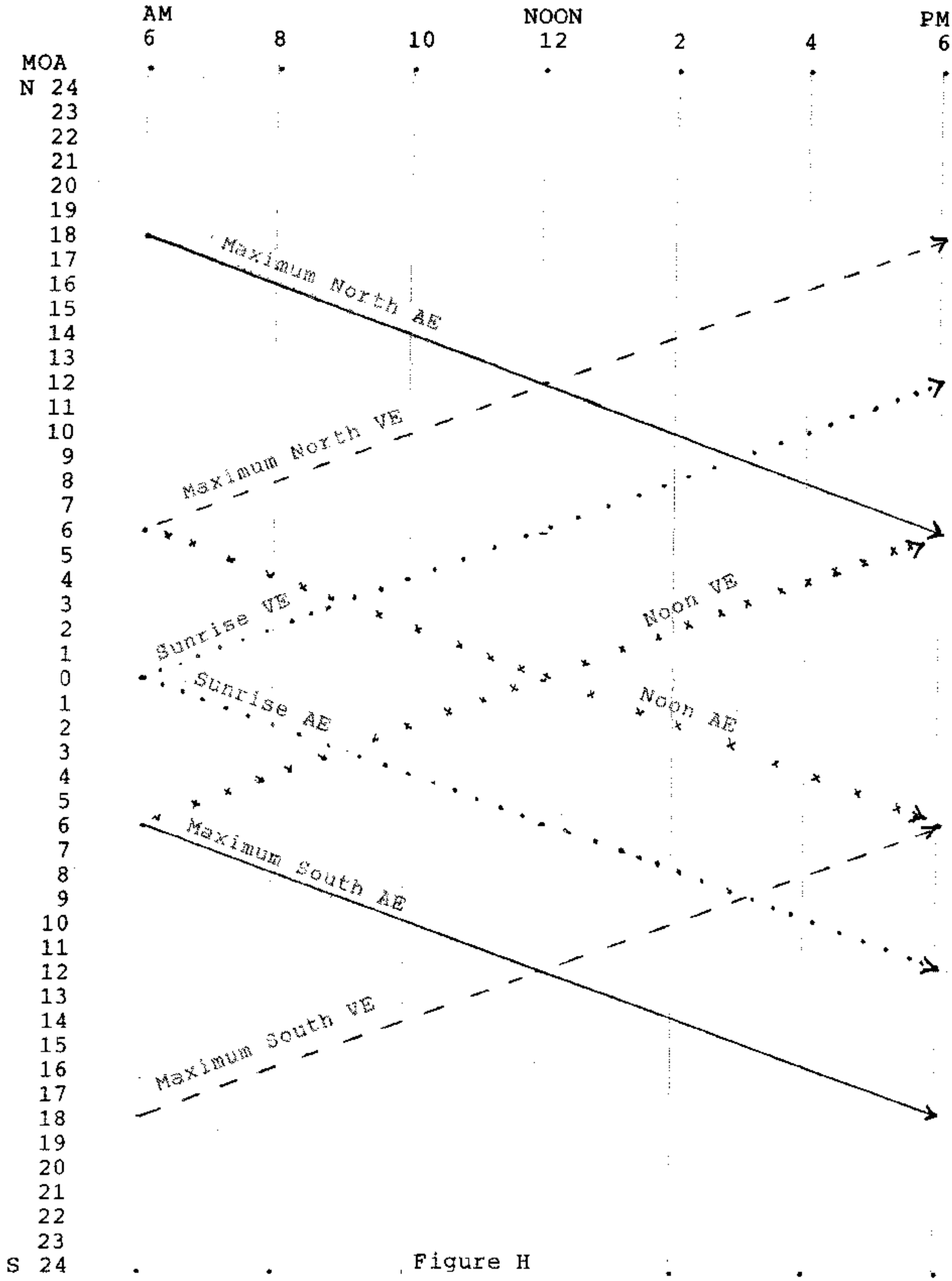


Figure H

alignment for.

Figure H (Equinox Declination Range and Change Over Daylight Hours) graphs the amount and direction of declination change over daylight hour for selected vernal (VE) and autumnal (AE) equinoxes within the range of possible equinoxes. It can be seen that a given equinox panel will achieve most accurate alignment based on the specific equinox or definition of equinox that the makers designed around, and that misalignments on other equinoxes will vary in a specific manner or direction of displacement which can be used to estimate the equinox assumption under which the alignment will be most precise. For example, a sunset panel which was designed to capture a maximum north VE (a VE for which the moment of equinox occurs at one minute after midnight local time) will for all other equinoxes have the alignment displaced in varying amounts in <u>one</u> direction due to the declinations of the sun for all other possible equinoxes being further south at sunset. The alignment or displacement of alignment on any equinox panel for any given equinox will suggest to the researcher the equinox for which that panel was designed. Under ideal conditions, examining all equinox panels of a culture group under all possible equinoxes would define exactly the parameters within which the group defined equinox.

An example from my research to illustrate the manipulation of equinox and panel information to achieve understanding is Panel 3 and the equinox of September 22, 1990. This equinox was variously listed as occurring on September 22 or 23 depending on the source of reference. The U S Naval Observatory and a combination of computer programs patched together by researcher Nal Morris finally narrowed the <u>local time</u> of the moment of equinox, to 11:55 PM on the evening of September 22 (Morris personal communications). I term this type of equinox a <u>split equinox</u>, where the moment of equinox local time is very nearly exactly between two days. The alignment on the 22nd would be a maximum north AE alignment, and the alignment on the 23rd could be thought of as very similar to a maximum south AE alignment (study Figures G and H). Under these specific conditioned, for which of the two days will alignment be the most accurate on a sunrise panel? A noon panel? A sunset panel? Will a given panel be designed to align perfectly with either the north or south extremes, or somewhere in between?

Panel 3 is a Normal, Precise, Solo, Multi-Date Interactive panel which displays alignments on the eight key dates of the solar year. The equinox alignment is probably the most spectacular of these, as a large horizontal sun arrow moves across the panel from observer left to right, eventually forming a rounded, cup-like point which aligns with features of the shield held by the male anthropomorph. This portion on the interaction occurs at approximately 10:45 AM Mountain Standard

Panel #3: September 22, 1990. Alignment with hook but not with shield.

Panel #3: September 23, 1990. Alignment with shield but not with hook.

Moment of Equinox at 11:55 PM, September 22, 1990

Plate 7

CROSSQUARTER PANEL DECLINATION TABLE
(based on 16°20')

Crossquarter: 16° ____ '

	MST.																			MST.	
	Mid 12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	12 Mid	
	1	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	11	↑
M	2	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	10	
A	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	9	
Y	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	8	
	5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	7	
&	AM 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	6 PM	F
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	5	E
N	8	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5	4	B
O	9	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	3	R
V	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	2	U
E	11	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	A
M	Noon	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5	26.5	27.5	28.5	Noon	R
B	1	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	11	Y
E	2	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	10	
R	3	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5	26.5	27.5	28.5	29.5	30.5	9	&
↓	4	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	8	
	5	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	7	A
	PM 6	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	6 AM	U
	7	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5	26.5	27.5	28.5	29.5	30.5	31.5	32.5	33.5	5	G
	8	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	4	U
	9	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	3	S
	10	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5	26.5	27.5	28.5	29.5	30.5	31.5	32.5	33.5	34.5	35.5	2	T
	11	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	1	
	Mid 12	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	12 Mid	

Figure J

Note figures are in Minutes Of Angle (MOA) declination North (N) or South (S).
November and May: Use the left hand timeline, reading down the table.
February and August: Use the right hand timeline, reading up the table.

Time. Plate 7 shows a critical portion of the interactive sequence for panel 3 on each of the two days in question. On the 22nd the alignment is seen to be low on the shield rings (a result of the sun being further north that the equinox for which the rings were designed) but appearing to achieve perfect alignment on the hooked element attached to the shield. On the 23rd, the alignment is apparently perfect with the rings of the shield, but high on the looked element as a result of the sun being further south than the equinox for which the hooked element was designed. Overall, the interaction seems about the same amount "off", but in opposite directions of the 23rd and 22nd, This suggests two possibilities, both of which can be tested by further observation of the panel on an AE occurring at or near local noon, or time of panel function. One possibility is that the makers designed this panel to display the range of possible autumn equinoxes in precisely the manner we have seen, one extreme displayed by shield alignments, the other extreme displayed by hook alignment. The other possibility is that the high and low differences blend or disappear when the moment of equinox is at the time of panel function, or "Panel Zero", so that the alignment of all elements appears perfect when the local moment of AE is at 11:00 AM. VE alignments remain to be investigated, and may simplify or obscure the picture.

It can be seen that applying these ideas and methods to the observation of known equinox panels over a period of years should reveal patterning which ultimately will help build a defensible picture of the Fremont concept of equinox.

The arguments and techniques above also apply to investigation of crossquarter panels; Figure J shows the possible hourly declinations for crossquarter, base on the hypothesis that crossquarter can be defined for our purposes as that twenty-four hour period, from midnight to midnight, during which the sun passes through 16 20' north or south, based on the alignments judged most precise at my research site.

I conclude that we do not understand how prehistoric Native Americans determined or conceived equinoxes and crossquarter dates, or if they designed for or favored VE over AE, or whether they understood the effects of the possible range of declinations for the day of equinox; and thus some objective means of acquiring data is needed before and speculative model is assumed to answer these questions. Further, we do not know if there was change in the concept or day of equinox, or in crossquarter days, over time or over geographic areas. Study of interactive panel alignments for various declinations and times of panel function on equinoxes and crossquarters can enable us to build and refine a model which suggests objectives based answers to these questions.

"SUPERNOVA" PANELS

We have shown examples using declination as one of Binford's "...durable unchanging characteristics that the events of the present share with the past" to date interactive panels within the reading accuracy of the panel, and to research the Fremont concept of Equinox. In this section we will examine the potential uses of declination to test a hypothesis for some rock art panels: that they represent the AD 1054 supernova. Barnes (1986), and Cornell (1981, pages 173-192) give overviews of the supernova hypothesis. Cornell has a good discussion of the history, criteria, and arguments regarding the hypothesis.

In brief, Chinese records report that on the evening of July 4, AD 1054, a "guest" star appeared in a certain portion of the sky. It was multihued, fluctuated in brightness, and appeared to the observer as the size of "half a mat". Japanese tatami mats are about three feet by six feet traditionally, which may give some idea of the apparent size of the phenomenon. The star was visible in the daytime for nearly a month, and was the brightest object in the night sky for nearly two years. Astronomers in this century have identified the Crab Nebula as the remains of the supernova. At the suggestion os astronomer Fred Hoyle, William Miller determined that on the morning of July 5, AD 1054 the supernova would have appeared within three degrees of the crescent moon, but only over western North America. Miller had noted rock art panels in the American southwest which consisted of a crescent moon and a cross or deeply pecked dot, which he came to believe, represented the supernova. Archaeoastronomers have since reported over twenty of these panels in the southwest.

Cornell sums up the criteria for description of a panel as a supernova site. They are: a representation of a crescent and a "star" (a cross or deeply pecked dot or circle), an occupation near the site for dates bracketing AD 1054, and a northeastern exposure to the horizon. As can be seen, the first criterion requires an inference that the crescent and star elements on the panel actually were meant to represent the crescent moon and the supernova. The third criterion assumes a fact not in evidence, IE, that the Native American observer would have placed the panel in a certain orientation to the phenomenon observed.
Thus, two of the three criteria rely on interpretation of symbolism or behavior without supporting evidence, and the third criterion (occupation circa AD 1054) could be met by any number of rock art sites about the southwest.

It seems likely that a people such as the Uintah Fremont, who can be demonstrated to have memorialized special days of the solar year by creation of panels having precise interactions on those days, would have used interactive technology to memorialize an event as spectacular as the AD 1054 supernova.

Thus, examination of a "supernova" panel for interactions on a specific day, and adjusting for declination change over the

Panel #15: A "supernova" panel

Plate 8

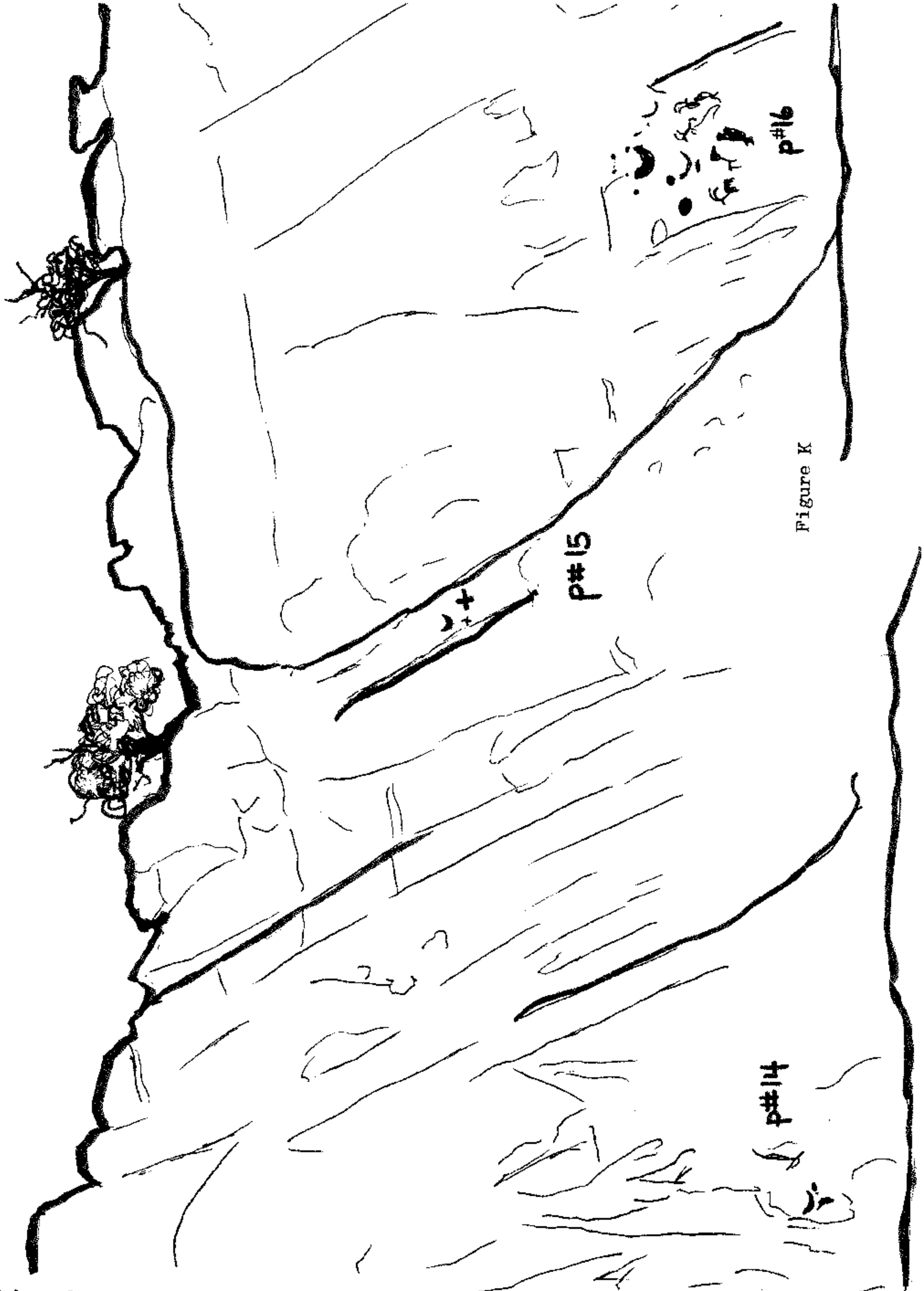


Figure K

last 1000 years, could either objectively support the hypothesis, or if "supernova elements were found to be interactive on other days, but not on the day of the supernova, suggest that the hypothesis was false.

A panel (Plate 8) composed of the requisite elements (crescent and star representations) was located at Cub Creek within Dinosaur National Monument. This panel was designated Panel 15. A pre-observation visit was made to the site on June 2, 1991 to determine the time for any potential interactions. At that time it was noticed that panels immediately to the left and right of Panel 15 also had the requisite elements. these panels were designated Panel 14 and Panel 16 (left to right). Figure K is a sketch of the panel locations. All three panels face southeast rather than being "exposed to a northeastern horizon", but as mentioned before, this criterion was based on an unsupported assumption. For the researcher of interactive panels, the working hypothesis, supported by data, is that panels will be on surfaces that have interesting natural shadow shapes in the day they are interactive, regardless of the orientation of that surface. As mentioned above, Truesdale has shown that AD 1054 is a tenable date for Fremont occupation at Cub Creek.

Panels 14, 15, and 16 were observed on June 7, June 8, June 9, and on June 2 (declination for summer solstice) 1991. Panels 14 and 16 have one interaction for these days; the segment we are concerned with falling between 11 AM and 1 PM Mountain Standard Time (MST). Panel 15 has a morning interaction (not recorded) and an interaction between 11 AM and 1PM MST. Photos (35 mm slides) were taken of the interactions on each of the four days. The slides for each day were then projected onto a sketch for each panel, and the interactions analyzed.

It is necessary here to interject that to analyze interactive panels, it is needful that the researcher be able to recognize and classify an interaction. An earlier paper (Johnson, 1990, #1) describes standard interactive shapes, and the nature of significant and precise interactions. Each of the shapes and interactions interpreted here as significant or precise has been observed and recorded at the author's main research site at another location within Dinosaur National Monument. The sun arrows described have been observed by the author at numerous sites around Utah, and photographed by other observers at many sites. Shadow line alignments are also extremely common. Thus interpretation of an interaction or portion of an interaction as significant or precise relies on data gathered from this site and others around Utah.

The data indicates a remarkable consistency for the selection and use of certain sun and shadow shapes, and the manner in which they are utilized. In explaining the interactions for Panels 14, 15, and 16 below, the first reference to a standard shape recorded by the author at the main research site will be followed by the initials MRS and the approximate number of time the shape is recorded for that site. For example: (MRS 3).

June 1991

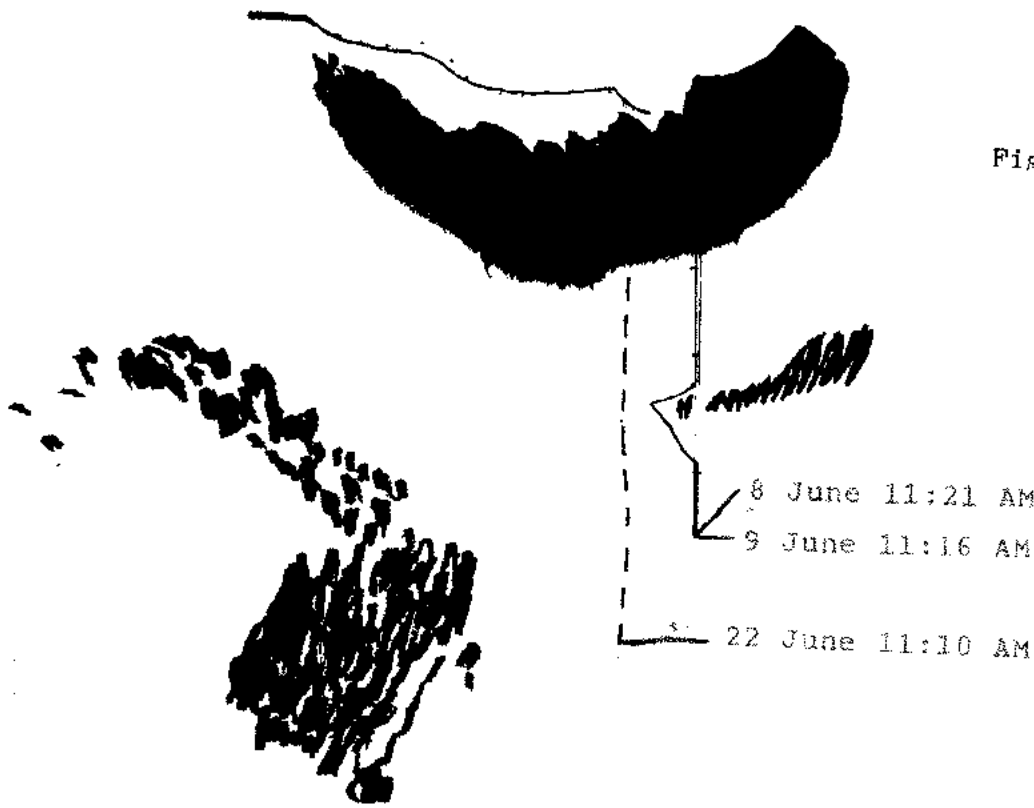
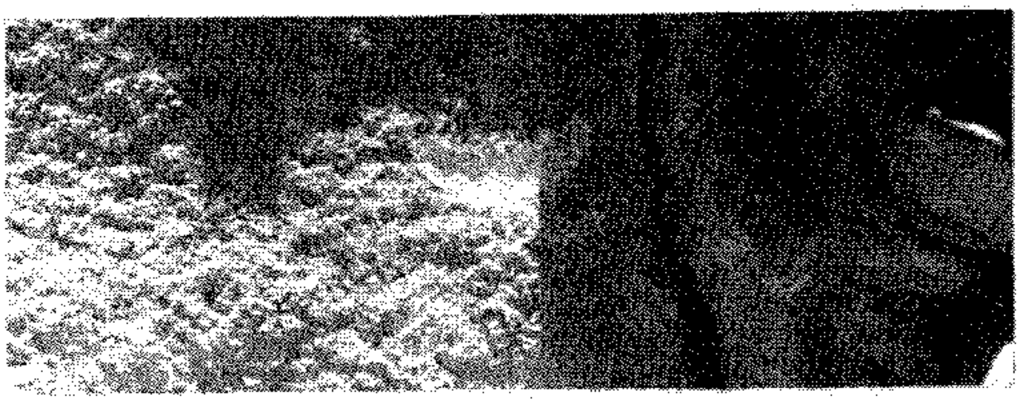


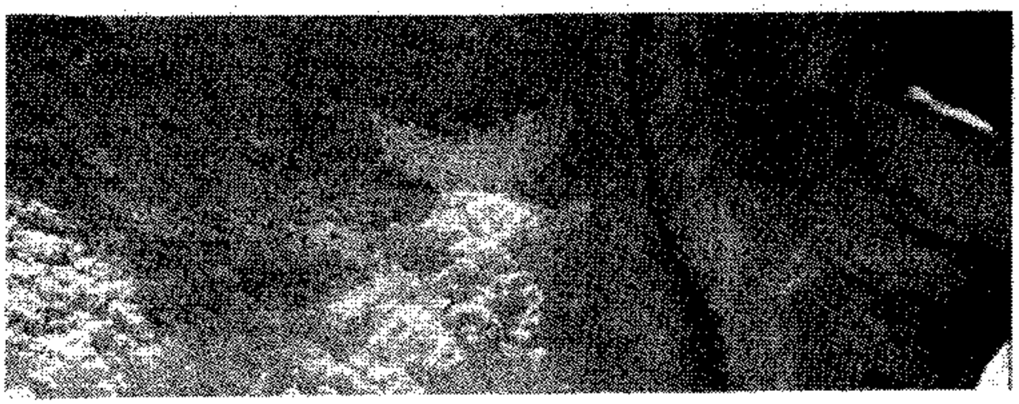
Figure L

It is also necessary to discuss the concept of complementary dates. Each day of the solar year, except for the day of summer solstice and the day of winter solstice, has a complementary date for the day of Vernal Equinox, for instance, is the day of Autumn Equinox. Days approximately equidistant on each side of a solstice are complementary dates, as can be seen by study of a declination table. This fact is often an aid to research, as it was in this instance, allowing observations to be made on the June complementary dates, so that if clouds or other problems interfered, a second chance was available in July.

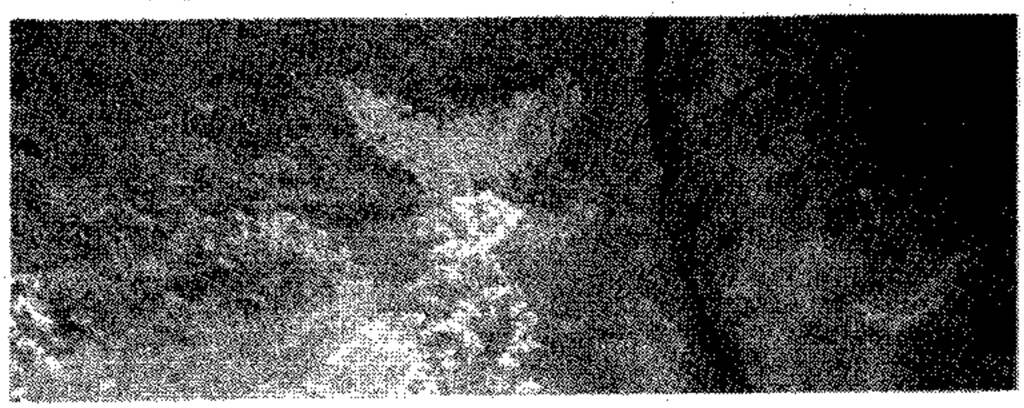
The first observation was that Panels 14, 15, and 16 are concurrent: they function at the same time, and can be related by elements as well as time of function (MRS 1).



CC Panel 14 11:16 AM



CC Panel 14 11:26 AM



CC Panel 14 11:28 AM

CC Panel 14 11:30 AM

Plate 9

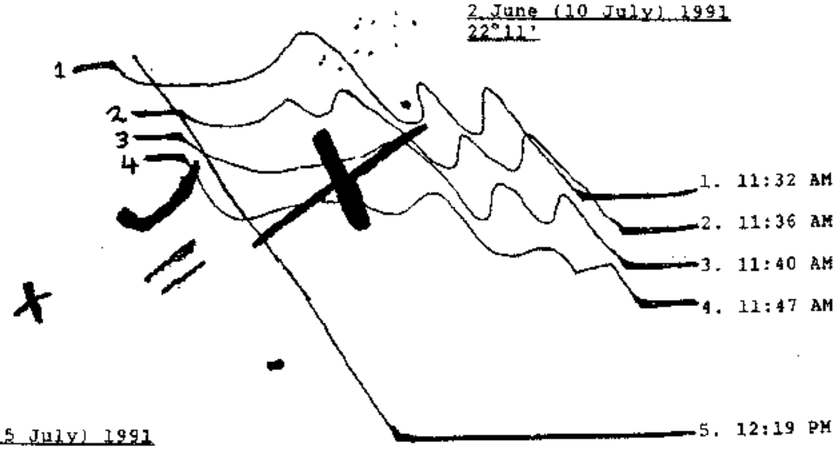


Figure M1

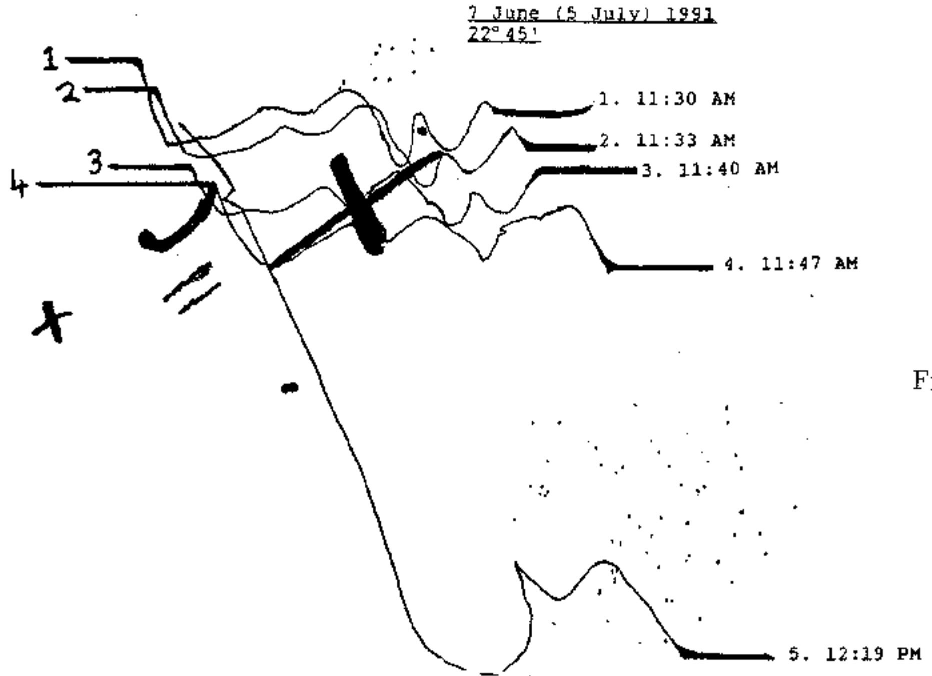


Figure M2

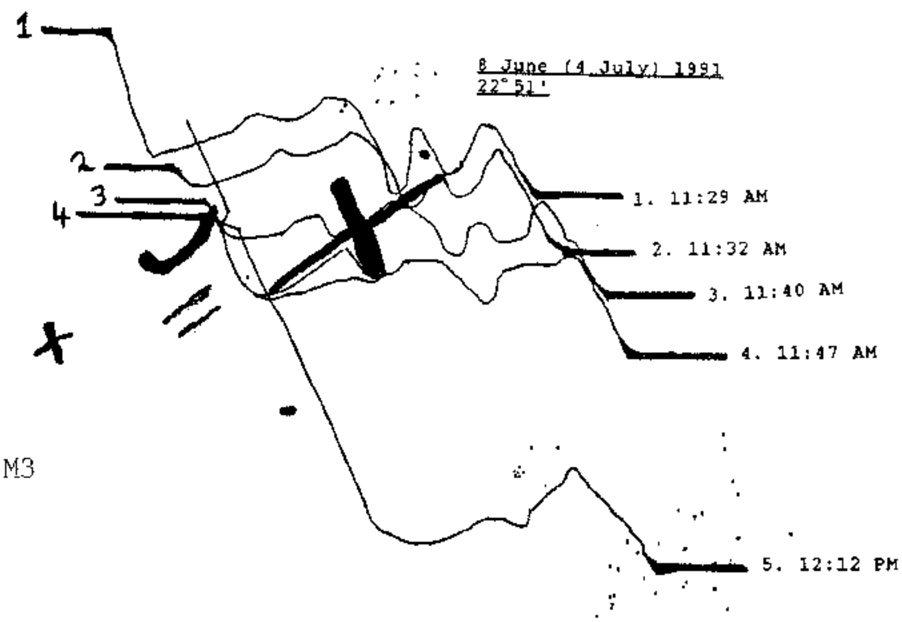


Figure M3

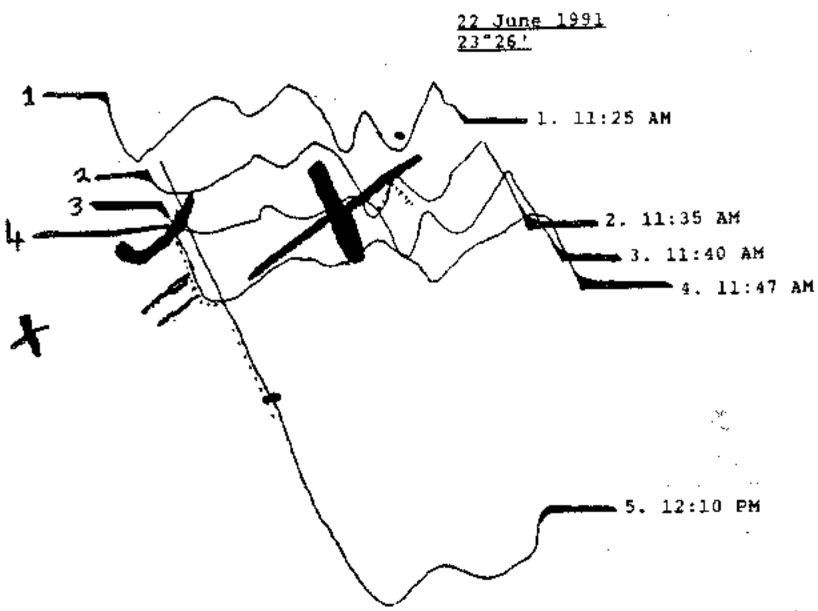


Figure M4

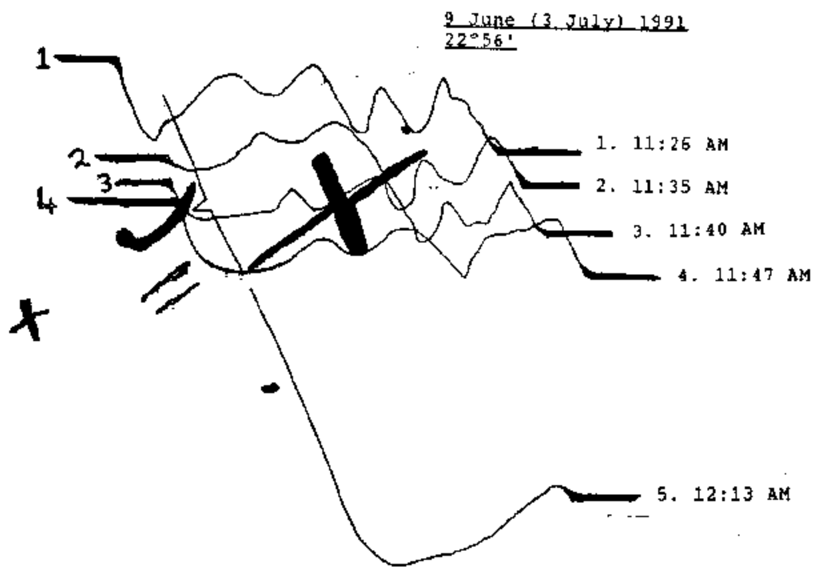


Figure M5

Figure L shows the significant portion of the interactions for panel 14 on June 8th and 9th, and on June 22. Plate 9 shows selected slides of the entire interaction on June 9th from 11:16 AM to 11:30 AM. The significant portion of the interaction begins with a shadow-mimic (MRS 2) of the crescent shape while a vertical sun line bisects the patinated area between two small patches of pecking (MRS 2) below the crescent . The horizontal shadow line slowly descends until at the lower limb of the crescent it becomes a sun arrow (MRS 20+) shining vertically down from the crescent. The arrow then becomes smaller and narrower while holding position (MRS 3) at the bottom limb of the crescent, until it disappears entirely. I would describe the sun arrow portion of this interaction as being seasonal (Johnson, 1990, #1) or symbolic in nature, and the precise portion as the vertical line bisecting the pecked patches. As can be seen on Figure L, the line position is essentially the same for June 8th and 9th (no photo for June 7th), and has moved left to a non-significant alignment by summer solstice (SS) declination on June 22. If we make the assumption that this panel is approximately 1000 years old, allowance for precession would move the line for the 22nd a millimeter or so further to the left.

Figures M1-M5 show the alignments for Panel 15 between 11:25 AM and 12:20 PM for the 2nd, 7th, 8th, 9th, and 22nd of June. Alignments are: sun arrow with dot (MRS 4+), sun arrow with end of an element (MRS 3+), sun arrow with angle of element (MRS 3+, and line with three significant points, the two ends of the cross and the end of the crescent (MRS 20+).

The dot above the right limb of the cross appears more heavily patinated than the cross, and is difficult to see in some lighting conditions. I didn't get close to the glyph, so whether this dot is a natural feature utilized as a part of an interaction (MRS 3+) or a pecked dot remains unresolved at this time. My opinion is that the alignments for June 8th are "best" (follow most exactly the type of alignment already recorded for the MSR) followed by the alignments for June 7th. I would describe the June 8th interactions as significant and precise. Alignments were slightly off for significant points on June 9th, and the alignments for June 2nd and 22nd do not show a series of sequential alignments with the cross of the crescent. These alignments are non-significant; however, on June 22nd there is an alignment for the "=" element and the dot below it. The dotted line on Figure M5 shows the SS alignment projected for 1000 years ago for three points in the interaction. Plate 10 shows six selected photos for the June 7th interaction.

Let us examine the third panel, Panel 16. Due to a "poor" surface for glyphs (MRS 2), the dimensions of the panel, small size of the elements, and lack of a good observation point (the trail comes very close to this panel and along a narrow ledge at

11:30 AM

11:33 AM

11:38 AM

11:40 AM

11:44 AM

11:47 AM

CC Panel 15 June 7, 1991

Plate 10

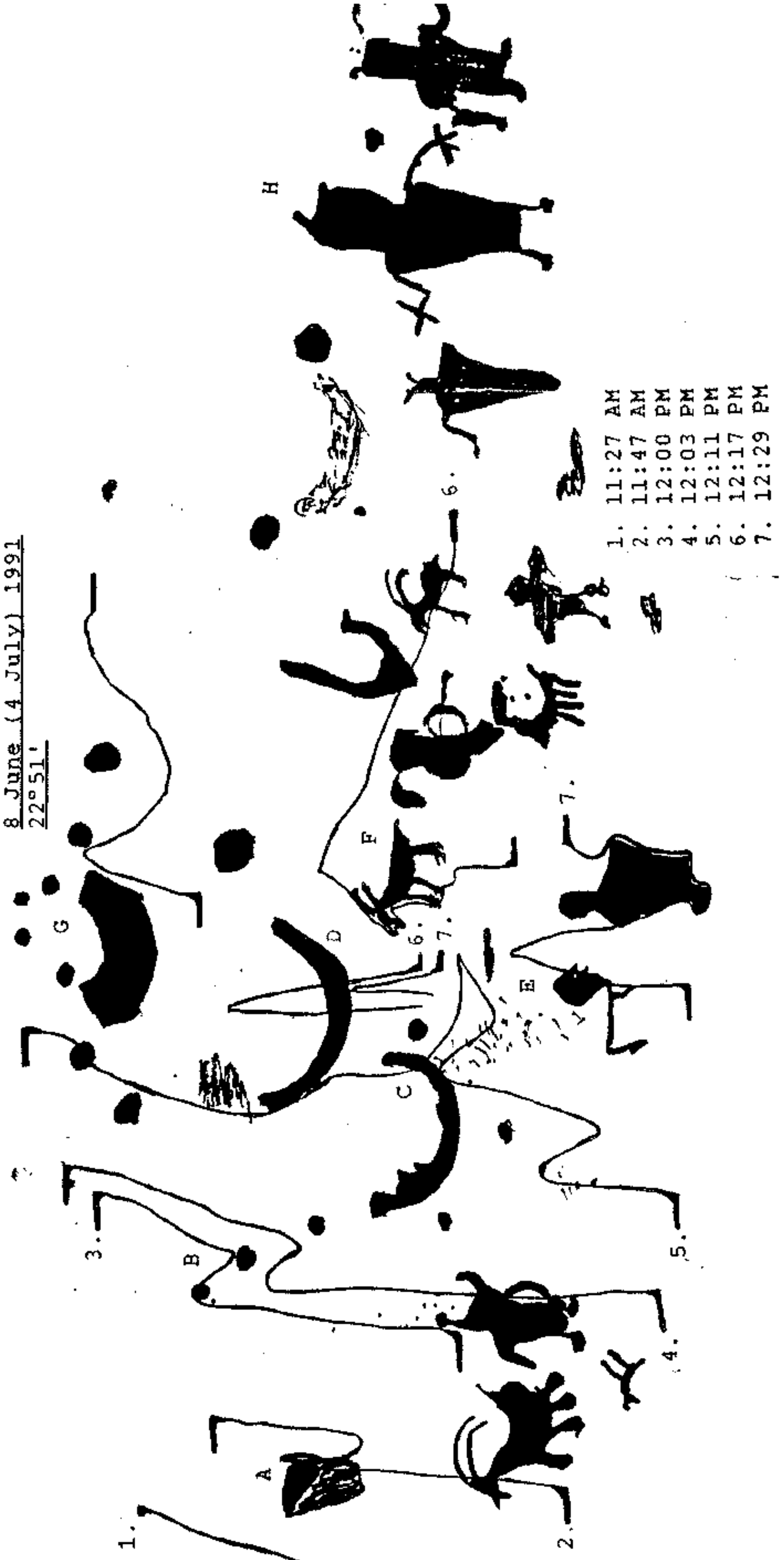

8 June (4 July) 1991
22°51'
1. 11:27 AM
2. 11:47 AM
3. 12:00 PM
4. 12:03 PM
5. 12:11 PM
6. 12:17 PM
7. 12:29 PM
A
B
C
D
E
F
G
H

Figure N1

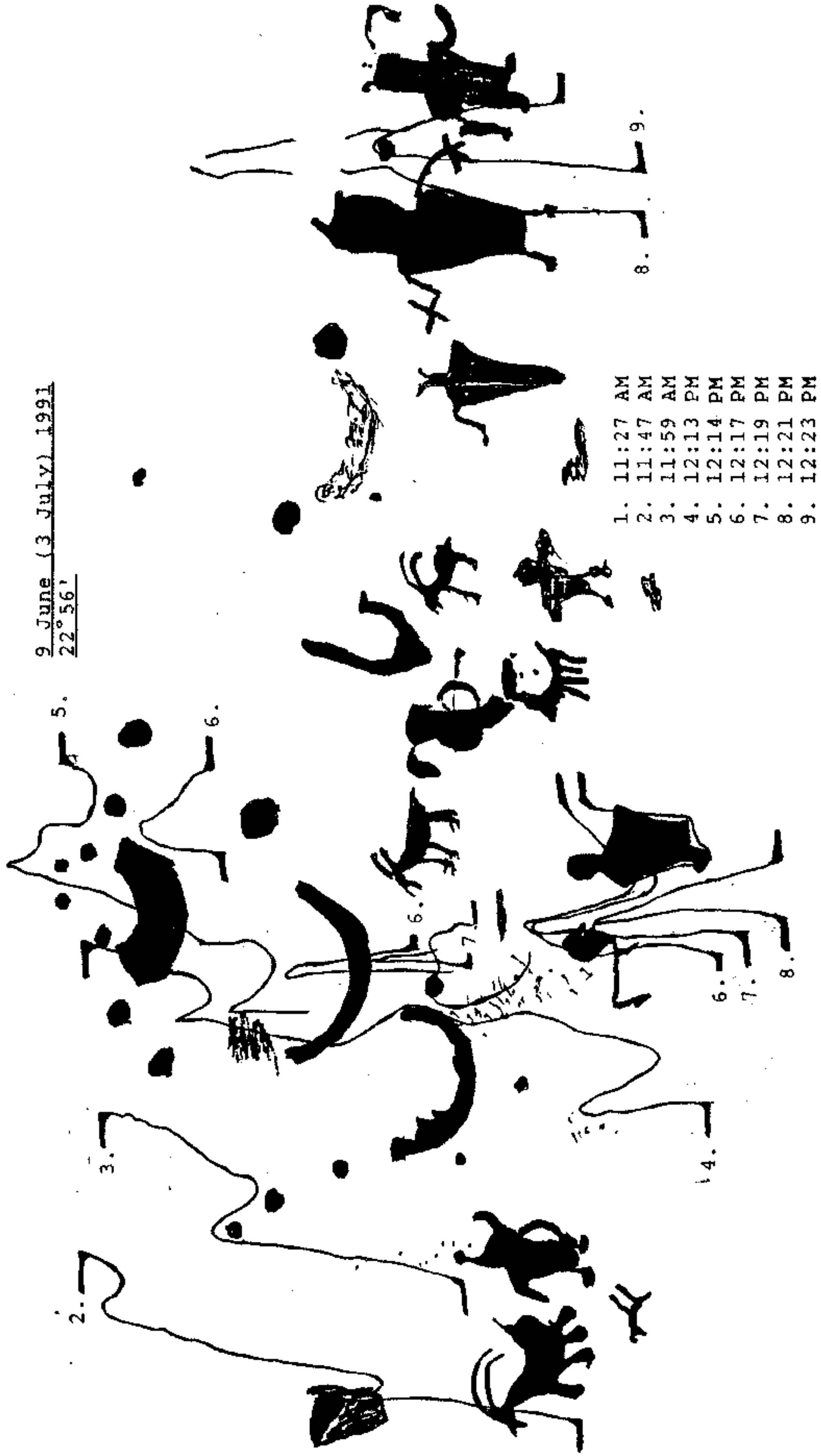

9 June (3 July) 1991
22° 56'
1. 11:27 AM
2. 11:47 AM
3. 11:59 AM
4. 12:13 PM
5. 12:14 PM
6. 12:17 PM
7. 12:19 PM
8. 12:21 PM
9. 12:23 PM

Figure N2

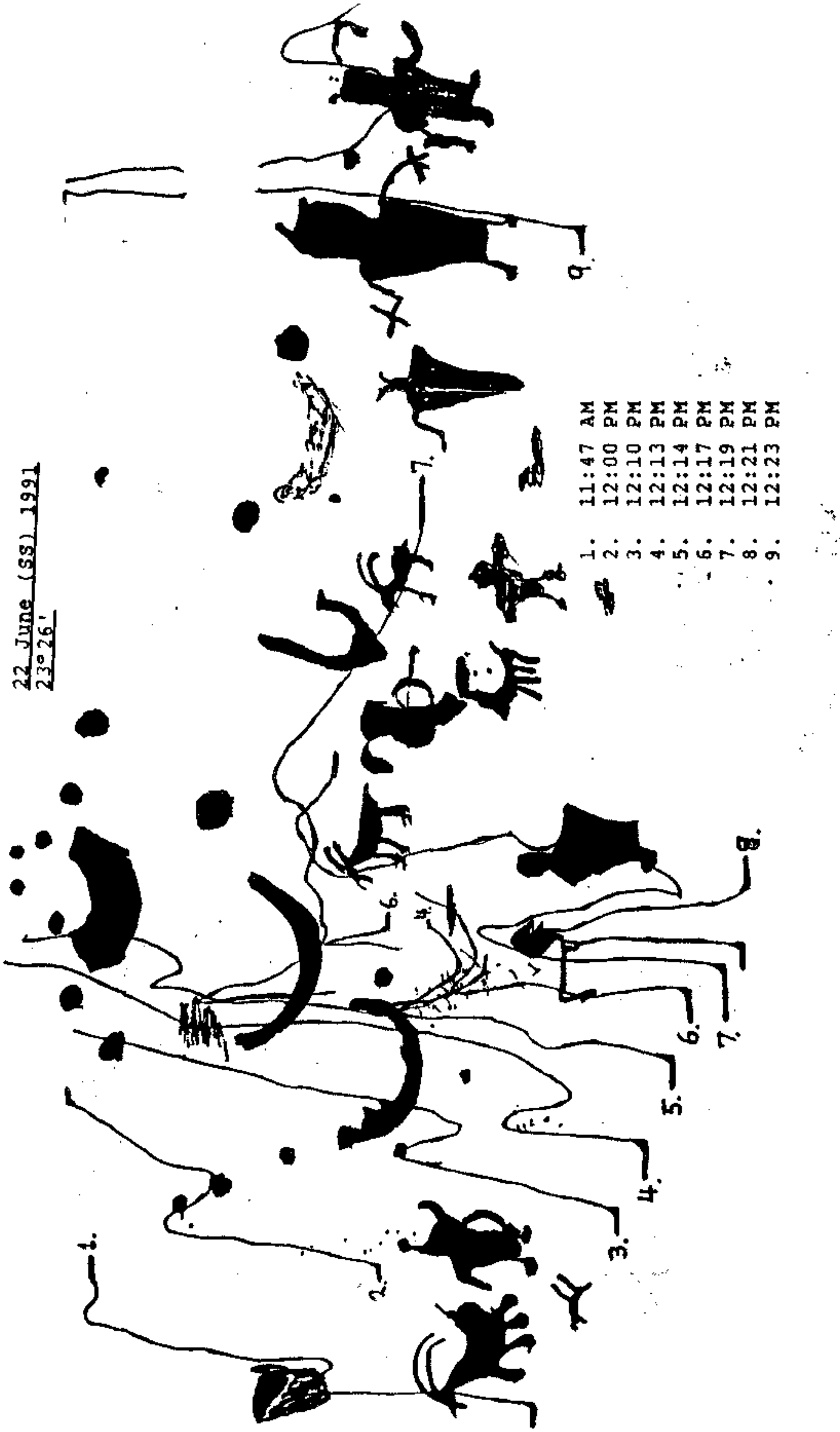

22 June (SS) 1991
23° 26'
1. 11:47 AM
2. 12:00 PM
3. 12:10 PM
4. 12:13 PM
5. 12:14 PM
6. 12:17 PM
7. 12:19 PM
8. 12:21 PM
9. 12:23 PM

Figure N3

this point), photographing the interactions and displaying them for the entire panel at one time was impossible. The interaction begins circa 11:15 AM and ends 12:30 AM. Figures N1-N3 show selected points on the interaction for June 8th, 9th, and 22nd. Observations for June 7th were incomplete. The interaction consists almost entirely of small, vertical, descending sun arrows the apexes of which align with specific points or which cup pecked dots on the Panel 16 for June 8th, with one photo from June 9th. Plate 12 compares the alignments at point B on Panel 16 for June 8th, 9th, and 22nd. I classify the interactions for Panel 16 at points A, B, and E as significant and precise. The paired sun and shadow arrows (MRS 1) are especially nice. Comparison of precise alignments at selected points of the interaction indicates the June 8th and 9th interactions are similar, with June 8th best at points A, and B, June 9th best at point D. The interaction for June 22nd is obviously off at points A, B, and E, displaying only the seasonal alignments of soft sun arrows with the bottom limb of the crescent as does Panel 14 at this date. No attempt was made to project the shift due to declination change over the past 1000 years on panel 16, which would have placed the pattern of interactions a few millimeters further to the left on the panel. Since all three panels face southeast and have superior gnomons, the sun and shadow pattern varies left or right with declination change on all three panels.

We must now translate our observations into a meaning full form to examine the supernova question, by calculating the declinations for SS and the time around July 5, AD 1054 and converting our observation dates to coincide. Two computer programs were used to determine the noon MST declination on the days of July 4th, 5th, 6th, and 7th for the year AD 1054. The two programs, called "Shamos" and "Kepler", disagreed approximately 3 MOA on the declination for each of the days (Nal Morris, personal communication). Figure P shows declinations for selected dates and their complementary dates, with "Kepler's" figures directly after each of the dates for AD 1054, and "Shamos'" figures in parentheses below. As can be seen, the observations on June 9th and June 8th, 1991 fall within the range of declinations for July 5th and July 6th AS 1054. Exactly where they fall within the range depends on whether one favors "Shamos" or "Kepler". TO resolve this matter it may be necessary to take real time tapes of the interactions on all three panels, analyze them frame by frame, carry all declination figures for both the days of observation and the dates for AD 1054 out to two decimal places, and a consult yet a third computer program. For our purposes, we will accept the declination for June 9th 1991 (22 56') as consistent with the declination for July 5th AD 1054, and the declination for June 8th 1991 (22 51') as consistent with the declination for July 6th AD 1054, using "Kepler's" figures.

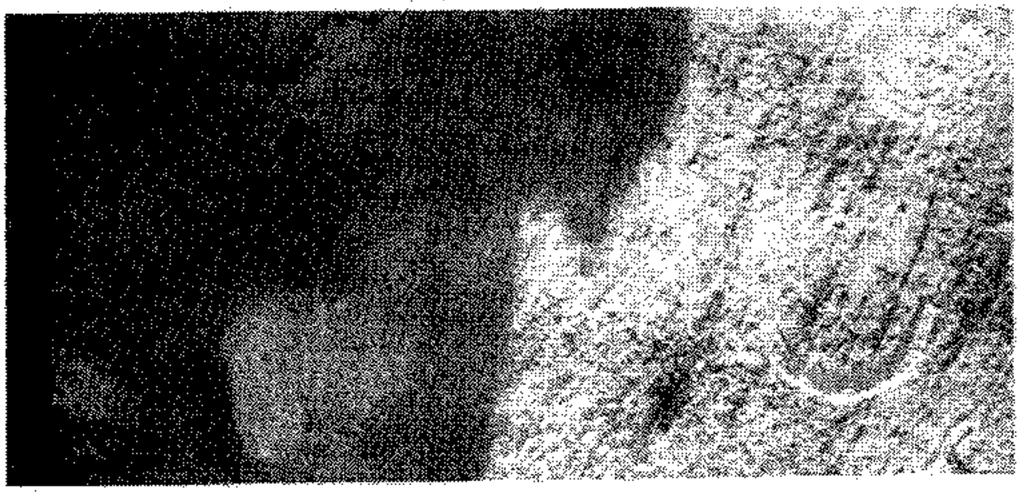
June 8, 1991 11:47 AM

June 8, 1991 12:00 AM

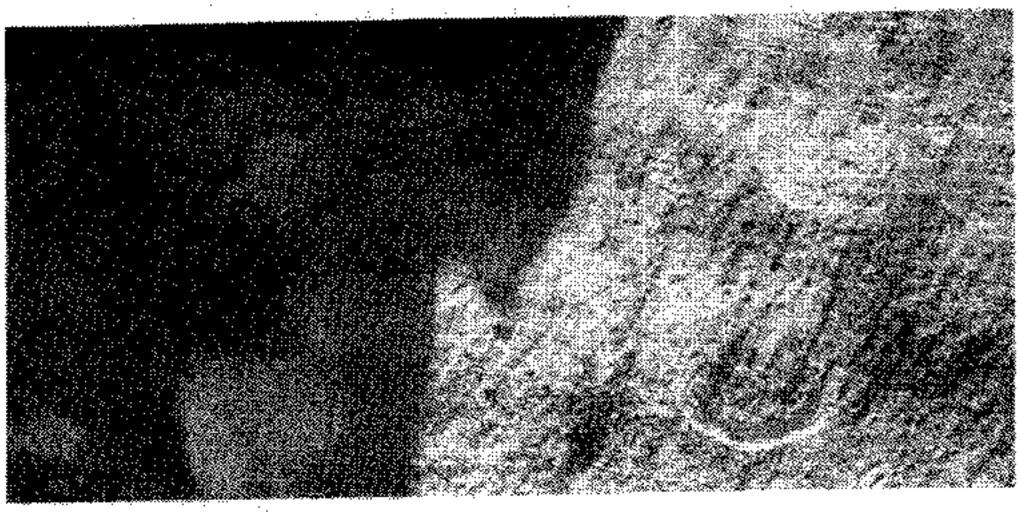
June 8, 1991 12:17 AM

June 9, 1991 12:21 AM

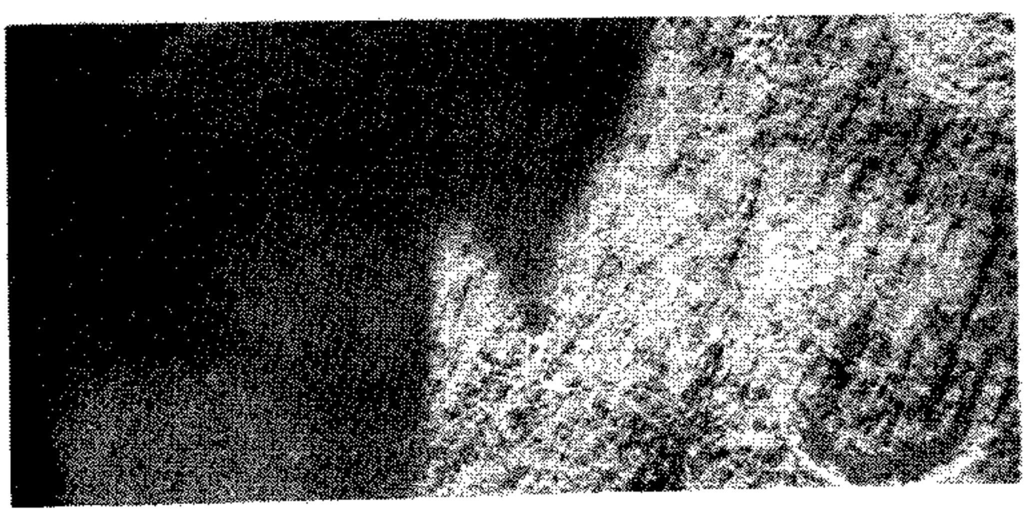
CC Panel 16 June 8-9, 1991 Plate 11



CC Panel 16 June 8, 1991



CC Panel 16 June 9, 1991



CC Panel 16 June 22, 1991

Plate 12

DECLINATIONS for SELECTED DATES

AD 1991 Date	AD 1991 Dec	1991 Complementary Date Date	1991 Complementary Date Dec	AD 1054 Date	AD 1054 Dec
				SS Jun 22	23° 34'
SS Jun 21	23° 26'			? Jun 26	23° 26'
Jul 2	23° 01'	Jun 10	23° 01'	Jul 4	23° 02' (22° 59')
Jul 3	22° 56'	Jun 9	22° 56'	Jul 5	22° 57' (22° 54')
Jul 4	22° 51'	Jun 8	22° 51'	Jul 6	22° 51' (22° 48')
Jul 5	22° 46'	Jun 7	22° 45'	Jul 7	22° 45' (22° 42')
Jul 10	22° 13'	Jun 2	22° 11'	? Jul 12	22° 11'

Figure P

Analyzing the observational data as summed up on Figures L, M1 through M5, N1 through N3, and Plates 9 through 12, we find that a majority of the precise alignments favor July 6th AD 1054, with some favoring July 5th AD 1054. If we were to use "Shamos'" figures, the average of the precise alignments would favor July 5th AD 1054. Alignments with "supernova" elements on the closest "normal" date for interactive panel alignments (summer solstice) were non-significant on all three panels. Careful analysis of the Plates and Figures will reveal that alignments for June 10th 1991 (equivalent to July 4th, AD 1054) can also be assumed to be non-significant.

I conclude that the interactions for Panels 14, 15, and 16 are consistent with precise elements on those panels being constructed for declinations equivalent to those of July 5th and 6th, AD 1054. Further, that interactions on these panels are unusual in that they do not align significantly on summer solstice. The elements found on Panels 14, 15, and 16 are consistent with the archaeoastronomic description of the AD 1054 supernova, and with the symbolic criteria expected for a panel supposed to represent the AD 1054 supernova. The symbolism of the interactions themselves, consisting of vertical arrows of light shining down repeatedly from representations of crescent moon-like and cross shaped or circular star-like elements, area suggestive of the event.

The pattern to the concurrent operation of the panels begins with the "moon" on panel 14 shining down, followed by the large cross shaped "star" on panel 15 shining down, followed by repeated "moons" and "star" on Panel 16 shining down, in conjunction with apparent attempts to depict details about the event symbolically. These include an apparent "zoomorphization" of the star, locating it as the head of a quadruped element, the inclusion in the interaction of a small kokopelli figure, and the fact that most of the sheep zoomorphs on the panel are depicted with their mouths open. The kokopelli figure may be used here symbolically to represent the idea that the new bright star was a "stranger" or a "visitor", just as the Chinese records referred to the supernova as a "guest" star.

I suggest a reasonable interpretation of these facts is that the precise elements found on Panels 14, 15, and 16 were constructed on July 5th and 6th, AD 1054 between 11:00 AM and 12:45 AM, in response to direct observation of the AD 1054 supernova on the morning of July 5th, AD 1054.

If we accept this interpretation, we now have three panels with different surface characteristics which we may use as a baseline for examining questions of repatination, wear or erosion, or dates for use of certain symbolic elements in Fremont rock art.

Other panels around the southwest United States identified as possible AD 1054 supernova panels need to be investigated for interactions.

Panels 14, 15, and 16 need further investigation to refine accuracy of observations, and to investigate the possibilities for other information inherent in interactive panels. It is conceivable that the panel makers may also have incorporated interactive information regarding the date the supernova could no longer be seen in the daytime, the sate the supernova could no longer be seen in the night sky, or they may even have designed elements on Panel 16 (which had a high albedo) to interact with the light from the supernova itself.

SUMMARY

This paper has discussed how understanding an aspect (declination) of the sun's apparent motion throughout the year and throughout the centuries can be used as a tool for dating certain rock art non-destructively, for understanding the concepts that led to the design of panels for certain dates, and for assessing the validity of current hypotheses about rock art itself. Examples were given using each technique, and an effort made to suggest needed improvements in the use of each technique.

CONCLUSIONS

As date-specific calendric artifacts, some rock art panels are far more accurate than previously believed.

Declination offers an objective, scientific tool for dating, understanding, and assessing hypotheses for rock art panels.

Interpretation of rock art panels or elements before investigating interactions is premature.

Interpretation of a single panel or part of a panel without investigating the entire site is premature.

The archaeoastronomic hypothesis for AD 1054 supernova panels is supported by archaeologic evidence derived from methodical observation of in-situ artifacts (Panels 14, 15 and 16).

There is a symbolic potential in the interactive shapes themselves, and in their relationships to the pecked elements of a panel, which far surpasses that of the elements alone. Interpreting, or even observing, a rock art panel without observing the interactions can be compared to watching a poster advertising the movie "Dances With Wolves" instead of seeing the movie.

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