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SATELLITE IMAGERY MEASURES OF THE ASTRONOMICALLY ALIGNED MEGALITHS AT NABTA PLAYA

THOMAS G. BROPHY*

EMCS Consulting
1161 Pacifica Place, Encinitas, CA 92024, USA

PAUL A. ROSEN

California Institute of Technology
Jet Propulsion Laboratory, 4800 Oak Grove Drive
Pasadena, CA 91109, USA

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Email: tgbrophy@earthlink.net
** to whom all correspondence should be addressed*

ABSTRACT

The Nabta Playa megalithic complex consists of two types of features: first are large stones, many of them shaped, placed on or in the sediments of an ancient seasonal lake bed that is now hyper-arid; second are large sculpted bedrock features underneath the sediments and associated with the surface megaliths (Wendorf et al. 1992). The astronomically aligned surface megalithic structures described in field reports (Wendorf and Malville, 2001) are identified in recent georectified 60 cm panchromatic satellite imagery of Nabta Playa, southern Egypt. The satellite images allow refinement, often significant, of the reported locations of the megaliths (Malville *et al.* 1998, and Wendorf and Malville 2001). The report that a primary megalithic alignment was constructed to point to the bright star Sirius, circa 4,820 BC, is reconsidered in light of the satellite data, new field data, radiocarbon, lithostratigraphic and geochronologic data, and the playa sedimentation history. Other possible archaeoastronomical interpretations are considered for that alignment, including the three star asterism (of Alnitak, Alnilam, and Mintaka) circa 6,270 BC that is also implicated in the small Nabta Playa 'calendar circle'. Signatures of other possible features apparent in the satellite imagery and a recent field study are also considered. Only a small number of the subsurface bedrock sculptures have been excavated. We recommend the use of ground penetrating imaging methods to illuminate the known but not yet excavated subsurface features. The problem of determining the astronomical intent of the builders of the megalithic structures is approached by considering the complex of features as a whole.

KEYWORDS: Nabta Playa, Egypt, megaliths, satellite, Orion's Belt, GPS.

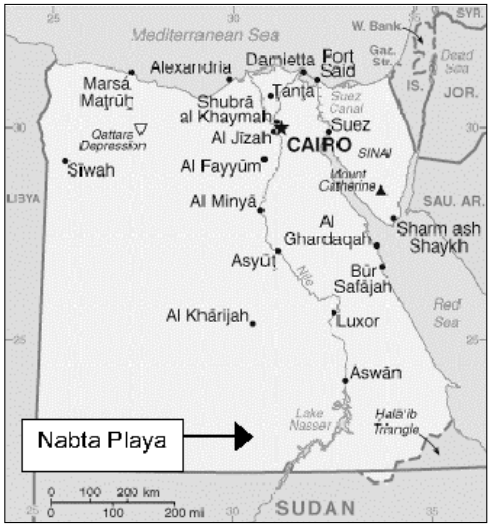

Fig. 1: Location of Nabta Playa.

WHERE ARE THE MEGALITHS?

After many years of excavating for Neolithic remains at Nabta Playa, Wendorf and team realized the site also contains many megalithic constructions. Wendorf *et al.*, 1993, reported the existence of a possible alignment of megaliths at Nabta Playa with an approximate azimuth of 10 degrees east of north. The possibly astronomical significance of these megaliths was reported in Nature magazine in 1998 (Malville *et al.* 1998). Malville et al. reported five lines of megaliths all radiating from a central point. The lines of megalithic slabs were reported to radiate out from the central structure of Nabta Playa, 'Complex Structure A'. A group of three northerly lines were reported at azimuths of 24.3, 25 and 28 degrees. A southeasterly line of slabs was reported with an azimuth of 126 degrees. And a due east alignment of slabs was reported with a surprising accuracy of 90.02 degrees. Coordinates of the megaliths were not reported.

In 2001, GPS coordinates for 24 megaliths, and Complex Structure A, at Nabta Playa were reported (Wendorf and Malville, 2001), based on simultaneous averaged measures from 6 to 10 satellites with an elevated antenna GPS. These values are repeated in table 1, columns 2 and 3.

Table 1	Wendorf and Malville 2001		Quickbird 2002		GPS 2003 (this article)	
Megalith	lat (degrees)	long (degrees)	lat (degrees)	long (degrees)	lat (degrees)	long (degrees)
A	22.5080	30.7256	22.5079	30.7255	22.5080	30.7257
A-1	22.5159	30.7299	22.5158	30.7297	22.5158	30.7299
A-2	22.5158	30.7297	22.5157	30.7297	22.5157	30.7298
A-3	22.5155	30.7299	22.5155	30.7295	22.5155	30.7297
"A3"						
A-0	22.5165	30.7306	22.5164	30.7305	22.5164	30.7306
A-4	22.5150	30.7297	22.5149	30.7295	22.5149	30.7297
A-X	22.5137	30.7290	22.5136	30.7287	22.5136	30.7288
"A2"						
A-5	22.5134	30.7291	22.5135	30.7290	22.5135	30.7291
A-6	22.5132	30.7290	22.5131	30.7287	22.5131	30.7288
A-7	22.5130	30.7288	22.5129	30.7286	22.5131	30.7289
A-8	22.5128	30.7288	22.5127	30.7286	22.5127	30.7287
A-9	22.5120	30.7283	22.5120	30.7283	22.5121	30.7284

"A1"						
B-1	22.5059	30.7303	22.5058	30.7301	22.5058	30.7303
B-2	22.5059	30.7302	22.5059	30.7300	--	--
B-3	22.5061	30.7300	22.5059	30.7299	22.5059	30.7300
B-4	22.5061	30.7298	22.5060	30.7297	22.5060	30.7299
"B2"						
B-5	22.5061	30.7294	22.5061	30.7292	22.5061	30.7293
B-6	22.5064	30.7287	22.5063	30.7287	22.5063	30.7288
B-7	22.5066	30.7283	22.5065	30.7281	22.5065	30.7283
"B1"						
C-1	22.5021	30.7330	22.5018	30.7331	22.5018	30.7333
C-2	22.5022	30.7331	22.5018	30.7333	--	--
C-3	22.5028	30.7327	22.5024	30.7325	22.5024	30.7327
C-4	22.5025	30.7329	22.5025	30.7327	22.5025	30.7328
C-5	22.5029	30.7323	22.5027	30.7331	22.5027	30.7333
C-6	22.5032	30.7317	22.5029	30.7320	22.5029	30.7322
"C1"						

Table 1: GPS coordinates for 24 megaliths and complex structure A at Nabta Playa.

The 2001 report (Wendorf and Malville, 2001) of more details of the megalith locations noted in the 1998 *Nature* article contains a curious aspect. The azimuths noted in the article, and used to derive stellar astronomy correlations, are significantly different from the azimuths one calculates from latitude, longitude coordinates given in the same article. Table 2 compares the megalith alignment azimuths given in the *Nature* article (Malville *et al.* 1998), with the 2001 site report (Wendorf and Malville, 2001), and with the azimuths that one may calculate simply from the 2001 site report coordinates. These calculated values are a simple average of the azimuth for each megalith considered to be in each line.

The alignment azimuths are the primary basis for calculating stellar correlations. An error of even one degree or less can significantly alter a stellar alignment date, and the significance of an alignment. So it is relevant to determine which of the reported megalith locations may be in error.

line	Malville et al. Nature 1998	Wendorf and Malville 2001	From Wendorf and Malville 2001	This paper
A3	24.3	16.557	26.83	25.86
A2	25	18.524	28.60	27.68
A1	28	21.194	31.24	30.00
B2		113.771	115.81	117.49
B1		116.174	118.97	121.11
C1	126	125.373	129.71	130.10

Table 2: Megalith Lines, Azimuth east of north (degrees).

December 31, 2002, the Quickbird satellite, less than a year after beginning commercial operation, acquired a high quality 60cm resolution panchromatic georectified image of Nabta Playa. Figure 2 shows a reduced resolution crop from the satellite image, showing the detritus rings from the excavations of Complex Structure A and Complex Structure B, and the megaliths labeled as lines B1 and B2 by Wendorf and Malville (2001). Figure 3 shows the individual named megaliths in line B1, as seen in the satellite image. By comparison with the individual megalith drawings and descriptions given by Wendorf and Malville, essentially all of the 24 megaliths and some of the Complex Structures were identified in the satellite image. Then the program *ERMapper* was used with the georectified image coordinates delivered by the satellite provider Digitalglobe, Inc., to measure the latitude and longitude of the megaliths. The Root Mean Square Error of the Georectified Quickbird imagery is measured to be 14 meters, and the circular error 90% measure is 23 meters, excluding viewing geometry and topographic displacement. (Digitalglobe corporation, 2003-2005.) These are the measured accuracies of the rectified pointing vector of the Quickbird images. The intra-image point-to-point measures within a Quickbird image, which are the essential measures relevant in this study, are very precise as for any physical single-matrix CCD type detector, affected only by relative topographic displacements within the geography of the image area. All the Nabta Playa megalith measures presented here are from a single 64 square kilometer Quickbird image. The vertical topography within Nabta Playa varies gradually and by only a few meters, as it is an ancient dry lake bed only slightly ablated. Our Quickbird image was taken only 5 degrees off nadir longitudinally and direct, zero degrees off nadir, latitudinally. The resulting intra-image relative accuracy of the megalith locations is significantly smaller than the sizes of the megaliths themselves. These values are given in table 1, columns 4 and 5.

For a third constraint on the megalith location data, the site was visited in October 2003. A handheld twelve channel Garmin Etrex GPS was used to record the coordinates of the 24 megaliths and the center of Complex

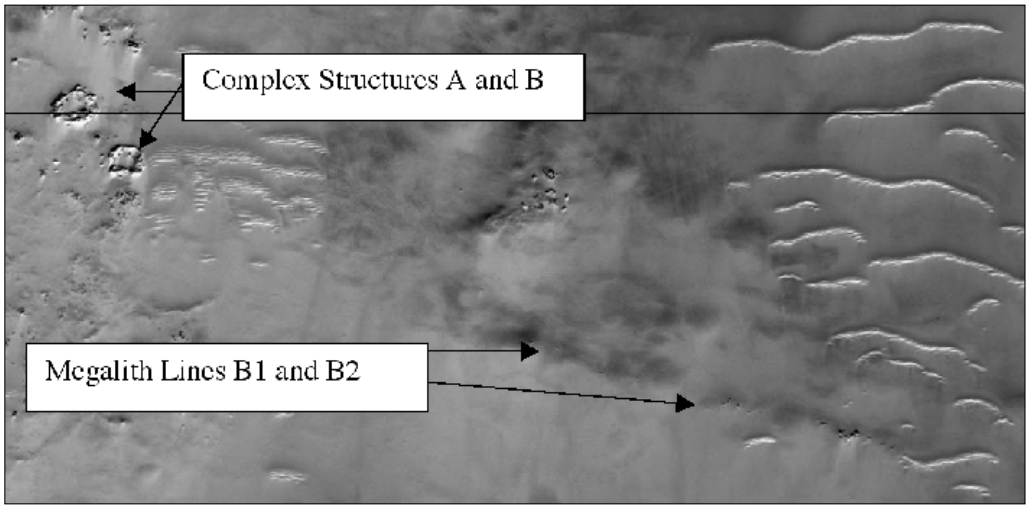

Fig. 2: Nabta Playa Center.

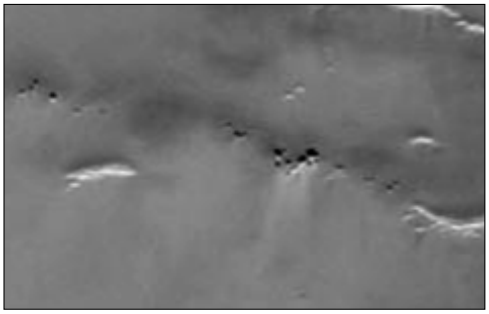

Fig. 3: Individual megalith fragments.

Structure A. This is a 12 parallel-channel WAAS (Wide Area Augmentation System) enabled handheld receiver with 1/second continuous update rate. Under a completely unobstructed sky, it was generally receiving 6 to 10 satellites simultaneously, with real time instrument-measured horizontal accuracies generally 4 to 6 meters. The GPS was simply held over the estimated center of the megalith or megalith fragments, and the coordinates recorded. These data are given in table 1 columns 6 and 7. During the measurements, the real-time instrument stated horizontal absolute accuracy was generally about 5 meters. The satellite imager was pointing 5 degrees off nadir east-west. Figure 4 shows the differences, in meters, between the satellite image-determined coordinates and the ground GPS-determined coordinates.

There is a consistent East-West offset, ground vs satellite, of about 12 meters, and generally no north-south offset. This indicates there was a small inaccuracy of the pointing vector for the satellite image. Thus both the 2003 ground GPS and the east-west pointing-corrected satellite determined measures can be considered essentially the same and very accurate. The most variant north-south megalith ('C-7') probably indicates visual identification on the ground of a different set of megalith fragments as the center for that megalith group.

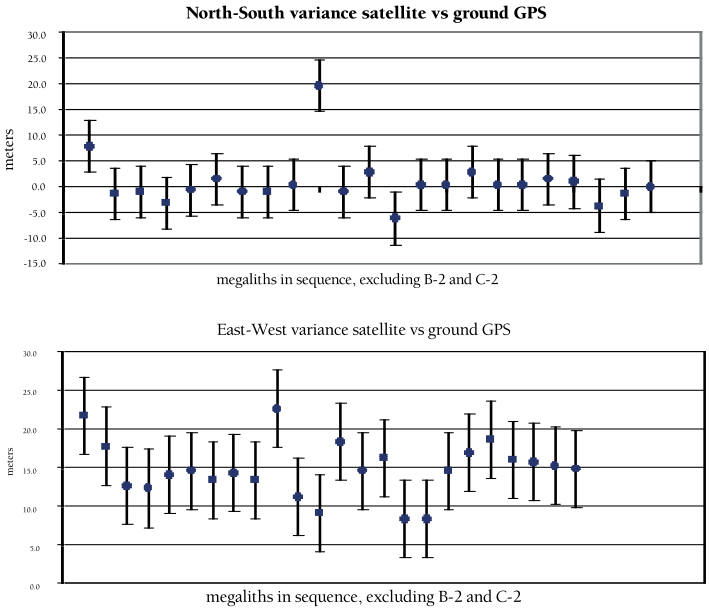

Fig. 4: Differences, in meters, between the satellite image-determined coordinates and the ground GPS-determined coordinates.

Now that clarified location coordinates for the megaliths are available, accurate azimuths from Complex Structure A can be determined. Table 2, column 4 gives the azimuths of the megalith lines, from the 2003 ground GPS measures and the pointing corrected 2002 satellite image.

WHAT DO THE MEGALITHS ALIGN TO?

Figure 5 illustrates the reported 1998 Malville et al. megalith lines with the reported 2001 Wendorf and Malville megalith locations, and with the reported 2001 Wendorf and Malville megalith lines.

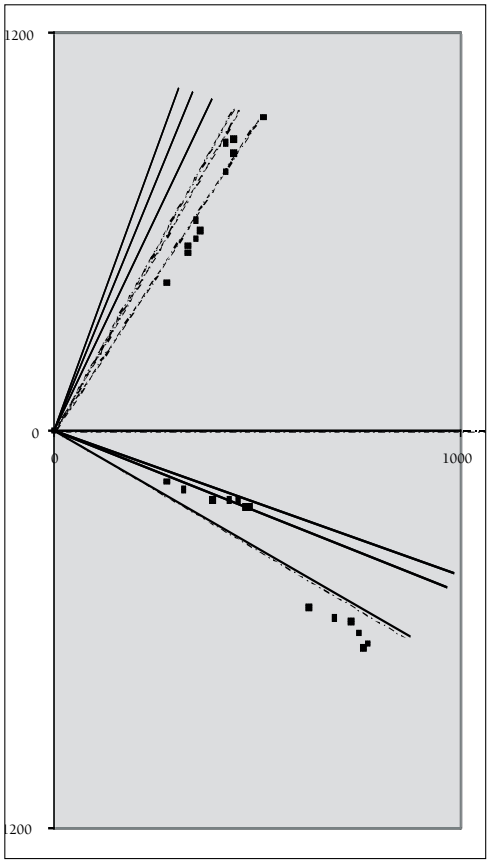

Fig. 5: Nabta Playa megaliths, previous 'locations'. Malville *et al.* 1998 (4dashed lines); Malville 2001 Scale marks in meters.

In Figure 5, the solid lines are the reported rising azimuths of stars ascribed to align with the megaliths, by Wendorf and Malville (2001). The northerly three solid lines were reported to be the rising azimuths of Ursa Majoris on the dates 4742 BC, 4423 BC, and 4199 BC, with azimuths (21.2, 18.5, and 16.6 degrees) respectively. The southerly most line was reported to be the rising azimuth of Sirius 4820 BC at 125.4 degrees. The other two southerly solid lines illustrate 116.2 and 113.8 degrees, reported to be the rising azimuths of the stars of Orion's Belt in 4176 BC and 3786 BC respectively. Thus Wendorf and Malville reported the Nabta Playa megalith builders marked the bright star Sirius *once* in 4800 BC, and tracked the precessional movement of the star Ursa Majoris on three dates from 4742 BC to 4199 BC, and they tracked the precessional movement of the three stars of Orion's Belt from 4176 BC to 3786 BC. However, here we show that the claimed alignments of those stars on those dates are significantly different from the locations of the megaliths.

It was considered if possibly the star date reports (Wendorf and Malville 2001) fit correct alignments to the megaliths, while the star azimuth numbers were in error. An independent calculation of the actual rising azimuths (declinations) of those stars on the dates reported finds the rising azimuths of the Orion's Belt stars were accurate (in Wendorf and Malville 2001) while the rising azimuths of Sirius and Ursa Majoris were significantly in error, however not in such a direction that correction of the error moves the star risings closer to matching the megaliths. We estimate that 4820 BC Sirius had a declination of -30.165 degrees giving a rising azimuth of 122.95 degrees. Figure 6 shows independently calculated rising azimuths, compared with the previous report.

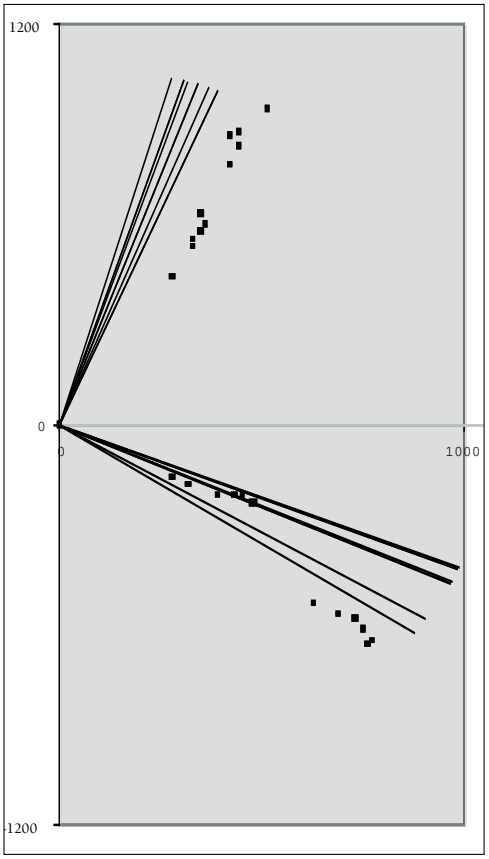

Fig. 6: Nabta Playa megaliths: previously claimed stellar alignments thin lines (Malville 2001), with declination corrections - heavy lines. Scale marks in meters.

So, what prominent stars aligned with the megaliths, when? The southerly most megalith alignment ('C' line) was reported by Wendorf and Malville to align with Sirius circa 4820 BC. Given these corrected data, we see that Sirius actually aligned with the C line circa 6000 BC. We estimate that 6088 BC Sirius had a declination of -36.51 deg, for a rising azimuth exactly on the C-line average given in Table 2. In Figure 7, plotted over the satellite image, the black line is the rising of Sirius in 4820 BC and the white line the rising of Sirius in 6000 BC.

The stellar correlations ascribed by Wendorf and Malville spanned more that 1,000 years and involved unrelated stars, with some of the stars purportedly being tracked through precession by the Neolithic megalith builders, and some stars not being tracked.

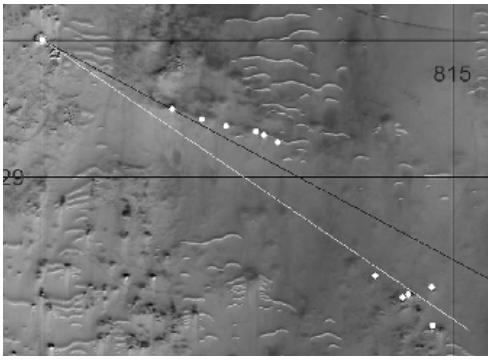

Fig. 7: Plotted over the satellite image, the black line is the rising of Sirius in 4820 BC and the white line the rising of Sirius in 6000 BC.

If we consider the complex of megalith lines, all on the same date circa 6270 BC, other possible stellar alignments become apparent. Figure 8 shows the rising azimuths of seven bright stars all on 6270 BC (Vega, the brightest star in the northern sky, and the three stars of Orion's Belt, and the three stars of Orion's head and shoulders: Betelgeuse, Bellatrix and Meissa). All of them have near fits to megalithic alignments. Figure 8 also shows that the Calendar Circle, located just off the edge of the ancient playa, is nearly in line with the many northerly megalith lines, such that it may be warranted to consider whether the Calendar Circle is related to the complex of megalithic structures and alignments.

INTENDED ALIGNMENT?

So far in this paper we have described the locations of many of the megaliths at Nabta Playa. We have also considered dates at which some selected stars aligned with some

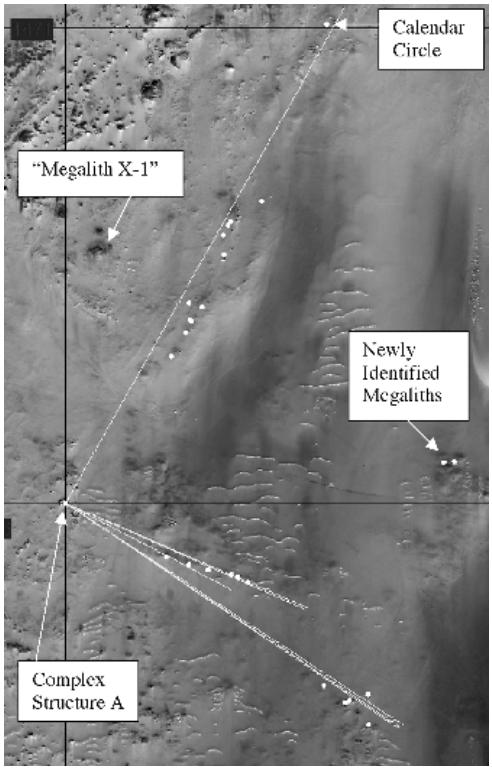

Fig. 8: The rising azimuths of seven bright stars all on 6270 BC. The Calendar Circle, located just off the edge of the ancient playa, is nearly in line with the many northerly megalith lines.

megalith lines. We now consider possibilities for what might have been *intended* meanings or alignments of the megaliths, intended by the builders of the site. Virtually all prehistoric or otherwise undocumented stellar alignments in archaeology have been challenged as statistically unproveable (e.g. Schaefer 1986).

The dates of activity at the site help constrain probable intended astronomy. Figure 9 plots all of the radiocarbon dates younger than 10,000 years collected from Nabta Playa (Schild and Wendorf 2001). We see the most intense radiocarbon activity around 6,000 BC, with steady activity continuing to the end of the last major humid

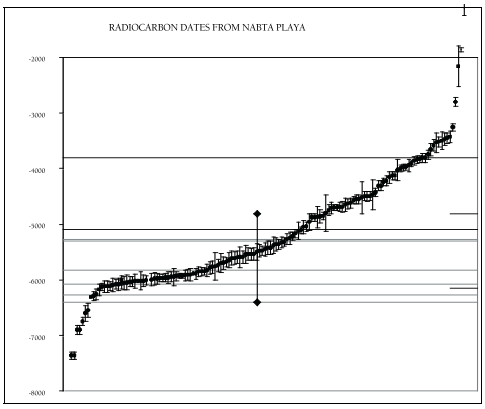

Fig. 9: Plotting of C-14 dates younger than 10.000 years from Nabta Playa.

interphase circa 5,100 BC, and continuing less actively to the beginning of hyperaridity and year-round uninhabitability circa 3,800 BC.

The heavy horizontal lines in figure 9 mark the beginning of hyperaridity and the end of the last major humid interphase at Nabta, which is also the end of major playa sedimentation. The end of the last major humid interphase is relevant to the timing of the placement of the megaliths. Many of the megaliths lay on top of the playa sediments, and so are believed to have been constructed there more recently than 7000 years ago (Wendorf and Malville, 2001). The corrected star declinations and megalith coordinates given here show that Sirius aligned with the southerly major line of megaliths more than 1000 years earlier, when the sediments were still accumulating.

This generates a number of questions about the megalith alignments. Is the primary, and earliest, alignment not intended for Sirius? Or, is a constraint that the alignments postdate the end of the last major humid interphase unnecessary?

Related questions involve the construction of 'Complex Structure A' (CSA). CSA consisted of a large oval of many megaliths, some finely worked, cut or broken, on the surface of about 3 meters of sediments

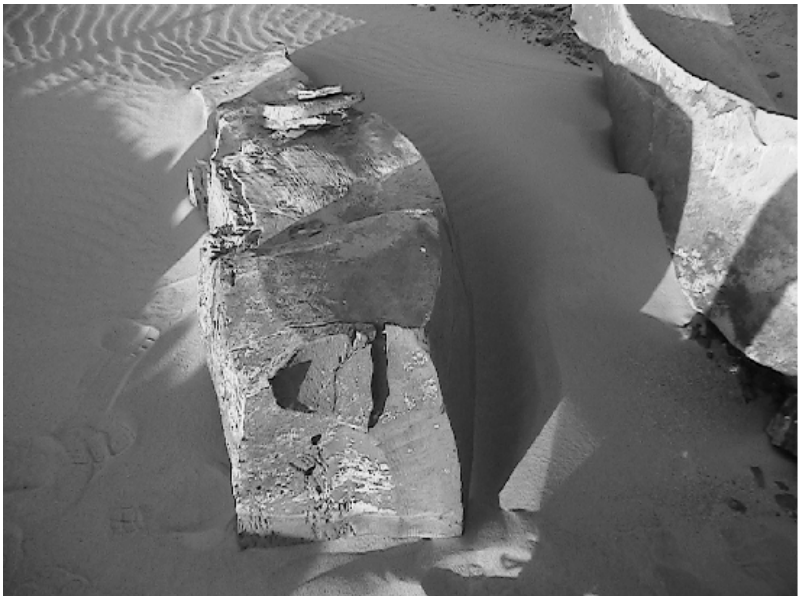

Fig. 10a: Broken, shaped megaliths at the surface of Complex Structure A. Footprints at the left give an estimate of scale

(Wendorf and Krolik 2001). Underneath those surface megaliths, on the bedrock below and still attached to the bedrock, was a sculpted lump of bedrock said to be 'shaped like a mushroom'. On top of the bedrock sculpture was a finely sculpted megalith, chocked in place by two other stones, all embedded in the sand underneath the oval of surface megaliths. All the megalith lines radiate out from this structure, indicating that CSA or at least some part of CSA, is the earliest of the megalithic constructions. Wendorf and Krolik theorize that CSA and 30 nearby similar Complex Structures were all constructed entirely after the sediments were lay down, with the builders locating subsurface bedrock lumps suitable for sculpting, using some unknown method for knowing what is under the sand. Given that parts of CSA, and the other Complex Structures, consist of sculpted bedrock under the playa sediments, it is reasonable to think that possibly something was constructed there before or during the playa sedimentation, and only the final stage of construction occurred at or after the end of the last major humid interphase. Similarly, if the original placement of CSA predated the end of sedimentation and if CSA is an element of all the megalith lines, that suggests that some of the megalith lines were also originally placed prior to the end of sedimentation. These megaliths, that now lay broken and cut on top of the sediments, may represent the final stages of construction, actually destruction, with the earliest constructions originating earlier.

A UNIFIED CEREMONIAL COMPLEX?

We suggest as an alternative model for the meaning of the megaliths at Nabta Playa that they may represent a unified complex of related meanings, including the Calendar Circle, as follows. The southerly lines of megaliths correlated with the three stars of Orion's Belt and with the shoulders and head stars of Orion all at the same epoch, circa 6270 BC.

That was also the observationally relevant time of vernal equinox heliacal rising for the center of Orion's Belt. The "scatter" in the

Fig. 10b: Megalith A-0, one of the smaller megaliths and one of only a few still standing.

megalith lines may be such as to coordinate with the vernal equinox heliacal rising of those same stars, spanning 6400 BC for the first star of Orion's Belt to 5200 BC. (These dates are marked in figure 9 by the thin horizontal lines.) And the northerly lines of megaliths correlated with the motion of the brightest star in the north, Vega, starting with Vega rising over the Calendar Circle circa 6400 BC and then passing over the other north megalith lines during the same time window. Interestingly, some of the southerly most megaliths may have also represented Sirius circa 6100 BC, for during that epoch the declinations of Sirius and Orion's Belt differed by less than 2 degrees. In a companion paper to this one (Brophy and Rosen, *in progress*) we will show that the standing stones within the Calendar Circle may have represented the appearance of the same stars on the meridian before summer solstice sunrise, during the same time period (6400 BC to 4800 BC).

CONCLUSIONS

The corrected megalith locations at Nabta Playa do not support the notion that the earliest alignment was built in order to point to the rising of Sirius at some time subsequent to the end of playa sedimentation (7200 years ago). If Sirius was the intended alignment, it had to have been built earlier, more than 8000 years ago. A compelling model for the meaning of the various astronomical structures at Nabta Playa may involve a consistent complex of meanings including alignments with the vernal equinox heliacal rising of Orion's Belt and the appearance of Orion's Belt on the meridian before summer solstice sunrise.

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