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Early Bronze Age Dolmens in Jordan and their orientations

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Abstract

This work presents the results of a survey of dolmen fields of the Early Bronze I in Jordan, in the Wadi Zarqa Valley, started in October 2004 and still in progress. Our data show, with a very high statistical significance, that in many sites of the Early Bronze IA a large majority of dolmens were built oriented along the N-S direction. A first interpretative hypothesis of these results, based on the astronomical contents of the mythology of the nearby civilizations culturally connected to the Palestinian area, is suggested.

Keywords: *Early Bronze Age; Dolmens; Wadi Zarqa; Orientations; Funerary Customs; Dumuzi*

Introduction

Dolmens and other megalithic structures, dated to the Early Bronze Age, are widely diffused in the whole Palestinian area (see, e.g. Prag 1995). These monuments are precious testimonies of the symbolism of the populations living in this area at that time, who did not left us written records of their world vision: actually, it has been clearly demonstrated in many other archaeological contexts that megalithic structures are often astronomically oriented and that these orientations could supply useful hints to the reconstruction of the religiousness of their constructors (see, e.g., Hoskin, 2001). However, in the specific case of the Early Bronze Age Palestinian sites, the archaeotopographic and archaeoastronomical studies of the megalithic monuments are scanty and only Belmonte (1997) performed a detailed archaeoastronomical survey of two dolmen fields (Ala Safat and Al-Matabi).

This work presents the results of a survey of dolmen fields dated to the Early Bronze Ia in Jordan (i.e. to the end of the 4th Millennium BC), started in October 2004 and still in progress: to date, we measured the alignment of a statistically significant sample of 79 dolmens in the upper Wadi Zarqa valley.

Measurements and data analysis

Measurements of the dolmens alignments were taken by using a compass, since the magnetic declination of the Wadi Zarqa valley was found to be zero, inside the instrumental precision (± 1°).

The dolmen alignment was estimated by the average of that of the two lateral slabs, since, most probably, these were the structural elements used by the builders to align the monument in a given direction (if any). In all cases where this measurement was possible (i.e., in all cases where the two slabs were standing in the original position or their original position was unambiguously determined), the parallelism of the two lateral slabs was found to be quite good and inside the instrumental precision, confirming the exactness of our hypothesis. We preferred to measure the alignment from the front of the dolmen: our choice is thus the opposite of the one of Belmonte (1997). The direction of the lateral slabs is actually easier to be precisely measured from the front, since in the opposite side it could be covered by the back slab. On the other hand, there are also significant archaeological reasons, that will be exposed in the following, supporting this choice. Our selected methodology of measurement makes obviously undetermined the elevation of the alignment: we have thus measured only the elevation of the local horizon in both directions of the dolmen axis, giving a lower limit for the elevation of the line of sight.

The number of dolmens aligned in angular bins of 8° was then computed in order to increase the statistics. The result were first checked versus the hypothesis of isotropic distribution in azimuth and, when a statistically significant peak was found, it was best-fitted by using Gaussians, in order to evaluate the hypothesis of a random distribution around a fixed direction.

We measured and analyzed in this way the alignments of a random sample of 44 dolmens (6.7% of the total and thus statistically significant) in the dolmen field of Jebel Mutawwaq, a Early Bronze IA site excavated and described by Fernandez-Tresguerres (1998), and a total of 29 other dolmens from four minor dolmens fields in the upper Wadi Zarqa valley (where we measured all the preserved dolmens).

Results

Jebel Mutawwaq

Our sample of dolmens from the Jebel Mutawwaq field is predominantly oriented in the meridian direction: 24 among them (54.5%) are oriented between 168° and 192°. A smaller, but still significant number (6) seems to cluster around the alignment of 152°. The orientation of the remaining 6 dolmens does not seem to have any preferred orientation. In particular, we do not notice any clustering in the E-W direction, but for a single case roughly looking East (see Fig. 1).

We further notice that two dolmens, though they are surely oriented along the meridian, have the mouths unambiguously looking in the opposite direction respect to the majority of the other ones.

The statistical significance of the excess counting between 144° and 192° (68.2% of the total) respect to the isotropic distribution is of 5.0 σ ; this excess is best fitted by the sum of two Gaussian, one centered on South and the second to 152°. This model has a statistical probability, evaluated by means of the reduced x^2 test, equal to 94%. The standard deviation of both Gaussian is of 6.5°, corresponding to a random error of the alignment of ±3.25°, most probably due to the precision achieved during the building of the dolmens.

Wadi Zarqa valley

If we consider the distribution of the whole sample of dolmens measured by us in the fields of the

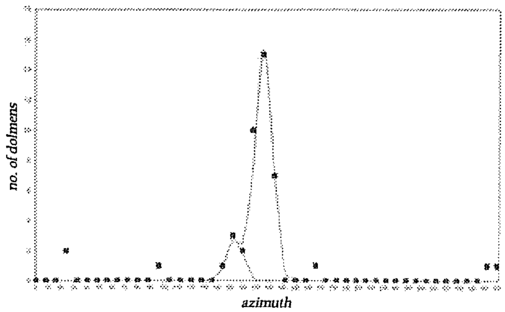

Fig. 1: *Angular distribution of dolmens measured in the Jebel Mutawwaq EB IA site*

Zarqa valley (including the Jebel Mutawwaq field; see Fig.2), the prevalent meridian orientation is still clear, being the 68.5% of them oriented between 144° and 192°. However, the spread of the distribution is higher and there is clearly a number of dolmens roughly oriented along the E – W direction, most of them found in a single dolmen field.

On the other hand, the excess of counting in the 144°-192° range is even more evident (with a statistical significance of 5.4 σ with respect to the isotropic distribution) and its statistical probability, evaluated by means of the reduced x^2 test, to be represented by the same model used in the case of Jebel Mutawwaq is equal to 99%.

We also notice that no dolmens clearly oriented to the opposite direction of the majority are found out of Jebel Mutawwaq.

Comparison between the Jebel Mutawwaq and Ala Safat dolmen fields

If we compare (see Fig.3) the distribution of the alignments of our sample of dolmens from Jebel Mutawwaq with the one of the Ala Safat field studied by Belmonte (1997), obviously rotating the orientations of the last one of 180° due to the different convention, we notice that they are extremely similar. The main differences are that in Ala Safat there is a number of dolmens oriented E – W and no dolmens oriented to the opposite direction of the majority. In the sum of the two samples, the excess of counting in

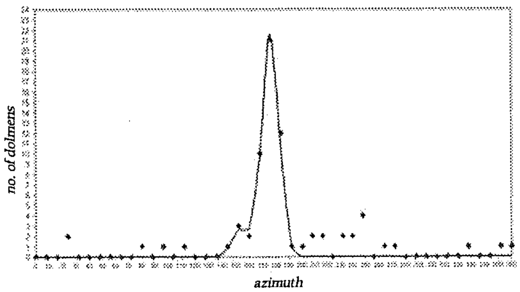

Fig. 2: *Angular distribution of the whole sample of dolmens measured in the Wadi Zarqa valley (including the Jebel Mutawwaq field)*

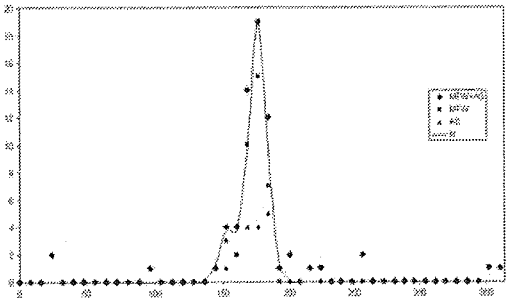

Fig. 3: *Comparison between the distribution of the alignments of our sample of dolmens from Jebel Mutawwaq (MTW) with the one of the Ala Safat (AS) field studied by Belmonte (1997)*

the 144°-192° range has a statistical significance of 6.2 σ respect to the isotropic distribution. However its statistical probability, evaluated by means of the reduced x^2 test, to be represented by the same model used in the case of Jebel Mutawwaq, though still high, is lower than in the previous cases, being equal to 85%.

Discussion

The data that we have presented clearly show that in many sites of the Early Bronze IA a large majority of dolmens were oriented along the N-S direction, with a very high statistical significance. We can thus first exclude the possibility that the dolmens were simply randomly oriented.

The possibility that they were oriented, because of practical reasons, along the direction of the slopes has been suggested by Kafafi and Scheltema (2005); however, in our sample, this hypothesis is ruled out by the previously reported statistical considerations and by the fact that dolmens oriented along the meridian are found on slopes oriented in many different directions.

It is thus reasonable to suppose that the dolmens were oriented along the meridian because of reasons in some way connected with the symbolic value of an astronomical object. It is evident that the meridian direction rules out any interpretation concerning the pointing to the rise or set of the Sun, the Moon or stars and indicates that the dolmens were oriented toward the culmination of one or more given asterism or celestial body.

If the actual direction of the alignment was North, the only possible choice are the Big Dipper and the Celestial Pole, as discussed by Belmonte (1997).

If the direction was South, there are many more possibilities. A number of ancient monuments are oriented South pointing the culmination of Sun or Moon, tough this is usually not the case for tombs. The "Taulas" in the Balearic Islands were oriented South, most probably pointing to the Culmination of the Crux – Centaur asterism (Hoskin, 2001). However, a number of the dolmens that we measured in the Wadi Zarqa valley have the southern physical horizon as high as 25° while the brightest stars of the Crux – Centaur asterism during the last centuries of the 4th Millennium culminated, at the Wadi Zarqa latitude, at the maximum height of 26°. This fact makes the Crux-Centaur an unlikely candidate for the Wadi Zarqa valley dolmens.

The most outstanding southern constellations visible in these locations and epoch during the winter, when most probably the dolmens were in use (see, A. Polcaro, 2006a), were Orion, Taurus (and Pleiades), Canis Major (and Sirius), Leo and Scorpius. One or more of these ones, or the Sun or the Moon, were thus the targets which the meridian oriented dolmens were pointing to, if the direction of the alignment searched by the builders was South.

However, as stated before, we have no written text from Palestine in the Early Bronze Age. It is thus difficult to have final proofs of the actual direction of the orientation from the mythology and customs of its inhabitants.

It is commonly assumed that, when a funerary monument is astronomically oriented, the direction of the orientation is the one going from inside to outside, since this alignment could be selected in order to help the soul of the death to reach a given location in the Sky. This is, for instance, the case of the Egyptian tombs, whose entrance points to the Northern Celestial Pole because it was believed to be the "place of rest" of the souls (see, e.g. Belmonte & Hoskin, 2002). We cannot of course rule out this hypothesis also in the case of the Wadi Zarqa dolmens. However, there is, to date, neither proofs of an Egyptian influence in the trans-Jordan region during the Early Bronze IA (see, e.g. A. Polcaro, 2006b and references therein) or of a peculiar importance of the Big Dipper in the Palestinian mythology of the same epoch. We cannot thus surely assume that the Wadi Zarqa dolmens were oriented to North as the Egyptian tombs.

On the other hand, we noticed the presence of a sort platform, or themenos, in front of most of the dolmens that we measured, indicating that some rite was performed there. It is thus also possible that these dolmens were built in such a way that he who officiated the rite was looking in the opposite direction, respect to the front of the dolmen.

In this hypothesis, a first interpretation of the measured orientations of the Wadi Zarqa dolmens should be suggested from the astronomical contents of the mythology of the nearby civilizations culturally connected to the Palestinian area. In particular, we have to consider the role of the myth of the god Dumuzi in the funerary customs of the Near East during the Early Bronze age.

Following the Mesopotamian myth (see, e.g., Botero & Lavender, 2004), Dumuzi was originally a shepherd whose marriage to the goddess Inanna (Venus) ensured the fertility of the land and the fecundity of the womb. This marriage, however, ended in tragedy when the goddess (because of a complex story) decreed that he be carried off to the netherworld for six months of each year: hence the barren, sterile months of the hot summer. However, at the end of each summer, Dumuzi comes back to the earth. His return causes all animal and plant life to be revitalized and made fertile once again. Dumuzi is considered by the Ancient Near East scholars a "western" god, i.e. its myth came to Sumerian from the West. It is thus probable that he was venerated by the shepherds of the Jordan Valley and of the nearby regions.

We also recall that the nomadic (or semi-nomadic) shepherds who inhabited Palestine between the end of the 4th Millennium and the beginning of the 3rd Millennium BC had a secondary burial funerary custom: the body was engraved in a first deposition until the decomposition of the flesh. Then, the skull and the long bones were collected and translated into common burials. There is clear evidence that the first deposition sites were the dolmens and that the translation of the bones from the primary to the secondary graves was made in coincidence with festivals connected with the Dumuzi myth (A. Polcaro, 2006b). It is thus reasonable to check if the orientation of the dolmens could be related with an asterism in some way associated with Dumuzi.

This god is often associated with the constellation of Aries, called in Sumerian 'MUL.LÚ.HUN.GA' (see, e.g. Rogers, 1998; Arcones, 2006). However, this association is late: following Ungnad (1944) the name of this constellation, that can be translated as "the hired man", was wrongly transcribed in the Babylonian epoch, when LÚ (="man") was erroneously substituted by LU (="ram") by a scribe. Only even since this constellation was called "Aries" and thus associated with the divine shepherd Dumuzi. Many scholars (e.g. Cohen, 1993; Pettinato, 1998) suggest that, in Sumerian epoch, Dumuzi corresponds to the constellation mul Sipa-zi-an-na (="The true shepherd of Anu"; see, e.g. Hunger & Pingree, 1984). This constellation is Orion. Other scholars (see, e.g. Arcones, 2006) consider mul Sipa-zi-an-na associated with the gods messenger Pap-sukkal, who is actually mentioned in the MUL.APIN, togheter with Dumuzi, in connection with this constellation. However, most probably this "angel", having an important role in the myth of Dumuzi, was associated only with the star α Ori, Betelgeuse, actually called suk-kal-lum (="the herald").

It is thus possible that the dolmens were oriented to South to allow who officiated the rite of the translation of the bones to look to the culmination of Orion, in order to ask the protection of Dumuzi.

Of course, these arguments remain highly speculative; however, our measurements give a further hint supporting this hypothesis.

What the 152° peak tell us?

Actually, a further, very significant question remains still open: what does the 152° peak in the distribution of the orientations means? We remember that its presence is highly statistically significant and that dolmens oriented in this direction are present in most of the fields that we have studied in the Wadi Zarqa valley, as well as in the Ala Safat field studied by Belmonte (1997), if we accept our convention for the dolmens orientation.

This direction is by far too South to indicate the direction of the rise of any constellation with a culmination height greater than 25°. On the other hand, it looks quite unusual that, in the same cultural context, two different celestial objects were associated to the funerary customs.

The reconstruction of the sky over the Wadi Zarqa valley at the end of the 4th Millennium on the Winter Solstice (made by using the "Planetario" positional astronomy code, Massimino, 2006) give us a possible hint for the solution: this direction represents the azimuth of the constellation of Orion, when it first look to be "standing". We incidentally notice that when this fact happens, the lower stars of the constellation have a height of 25°, the maximum elevation found for the physical horizon on South of the measured dolmens: this means that all dolmens in our sample were built in such a way that whoever faces the dolmen was able to see the whole figure of Dumuzi, when the god was "standing up".

On the other hand, neither from the geographical or the astronomical point of view, the 152° azimuth can have any other possible meaning, but for the previously described one concerning Orion.

We can thus suggest that most of the Wadi Zarqa valley dolmens point to the culmination or to a peculiar position of Orion near to the Winter Solstice and that this fact could be explained by the role of the myth concerning the god Dumuzi in the funerary customs of Palestine in the Early Bronze age.

However, further studies are needed before to reach a final interpretation of the Wadi Zarqa dolmens alignments.

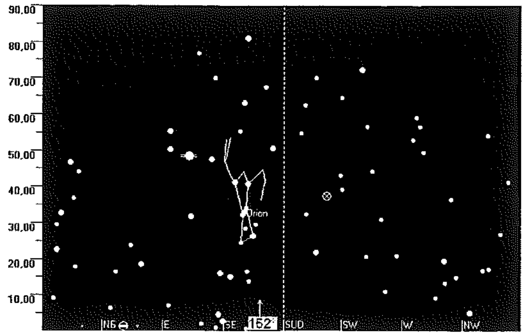

Fig. 4: *Reconstruction of the sky over the Wadi Zarqa valley at the end of the 4th Millennium on the Winter Solstice*

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Observational archaeoastronomy at the Newark Earthworks

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Abstract

The Newark Earthworks are the largest set of geometric earthworks in the world. Built nearly 2,000-years ago by the Hopewell culture of eastern North America, this ceremonial complex, is located in Newark, Ohio, and extended over more than twelve square kilometers. In 1982, Hively and Horn demonstrated that the main axis of the Octagon Earthworks was aligned to the northernmost rising of the moon, an event that occurs every 18.61 years. The period from 2004 through 2007 includes this cycle's northernmost rising of the moon (14 September 2006) and many near-northernmost risings that afford a series of opportunities to attempt to use the earthworks as a device for making observations of the moonrise. Direct observations made during this period indicate these earthworks function admirably and dramatically as a frame for observing the northernmost rising of the moon. These results support Hively and Horn's argument that the architecture of the Newark Earthworks deliberately encodes lunar alignments and adds insight into how the Hopewell culture would have experienced such astronomical events.

Keywords: *archaeoastronomy, earthworks, lunar alignments, Newark Octagon, Newark, Ohio, USA.*

Introduction: The Newark Earthworks

The Newark Earthworks are the largest set of geometric earthworks in the world (Lepper 1998, 2004). These monumental works encompass a series of gigantic earthen enclosures and mounds covering more than twelve square kilometers. Built between 100 B.C. and A.D. 400 by the people known to archaeologists as the Hopewell culture, the site originally included two large circular enclosures, one of which was linked to an even larger octagon, an oval earthwork surrounding a dozen mounds of varying size and shape, and a perfectly square enclosure, all interconnected by a network of parallel-walled roads (Fig. 1).

Much of the Newark Earthworks has been

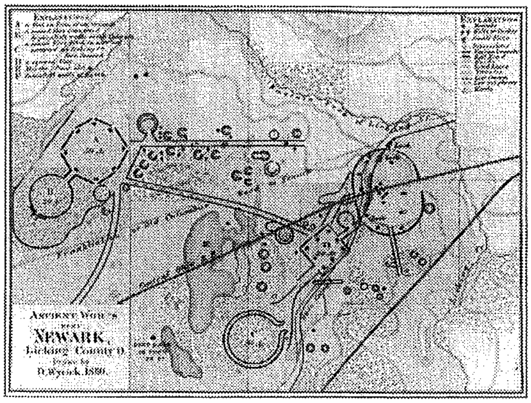

Fig. 1: Wyrick map of the Newark Earthworks ca 1860.

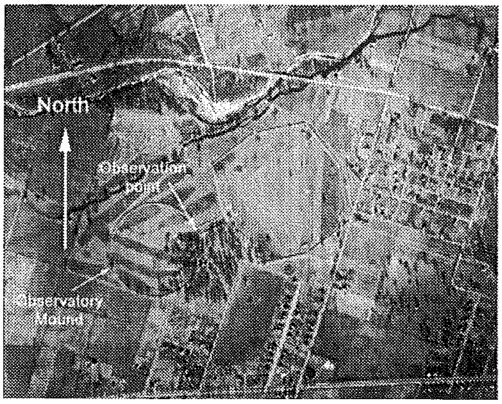

Fig. 2: 1934 Aerial view of existing Newark Earthworks, photo from National Anthropological Archives, the Smithsonian Institution, Washington, D.C., USA.

destroyed by agriculture and by the growth of the modern city of Newark, Ohio, but two major elements are preserved as islands of ancient grandeur within the 21st century urban landscape. The Great Circle is a prodigious circular enclosure 366 m across. The walls of the Great Circle enclose an area of about 12 ha. The circular wall varies in height from one to four meters with a ditch or moat at the base of the wall inside the enclosure. The ditch varies in depth from two to four meters. The Great Circle was preserved initially when the community established the county fairgrounds on this site in 1854. Since 1933 it has been owned by the Ohio Historical Society and operated as an archaeological park. The Octagon Earthworks consist of a circular enclosure connected to an octagon by a short section of parallel walls (Figure 2, Reeves 1934). The circular enclosure forms a nearly perfect circle 321 m in diameter and 8 ha in area. It deviates from a perfect circle of that diameter by less than one meter. The walls of the octagonal enclosure were each about 168 m long and from one to two meters in height. The combined elements enclose an area of 248,000 m^2.

The citizens of Newark and Licking County purchased the Octagon Earthworks in order to preserve the site, while providing the Ohio National Guard with a summer campground. By 1908 the National Guard had moved on to a different location, so, beginning in 1910, the Newark Board of Trade began to lease the earthworks to Moundbuilders County Club and the site became a golf course. In the 1930s, the Newark Board of Trade was dissolved and the property was deeded to the Ohio Historical Society. The Historical Society continues to lease the site to the same private country club.

The "Hopewell culture" is an archaeological culture defined on the basis of certain kinds of artifacts, architecture, and cultural practices that archaeologists have recovered in southern and central Ohio (and other regions of eastern North America) dating to between 100 B.C. and A.D. 400 (Lepper 2005). The people, whose sites are attributed to this culture, were farmers, fishers, hunters, and gatherers of wild plant foods. They lived in small villages scattered along the major tributaries of the Ohio River – especially the Great and Little Miami, the Scioto and Muskingum rivers.

The Hopewell culture is best known for their gigantic earthen mounds and enclosures and for the magnificent works of art they crafted from materials gleaned from the ends of their world: copper from the upper Great Lakes, mica from the Carolinas, shells from the Gulf of Mexico, and obsidian – a black volcanic glass – from the Rocky Mountains. These exotic materials may have come to Ohio as valued commodities in a network of trade, but we have little evidence for what the Hopewell traders might have given in exchange. Knives and bladelets

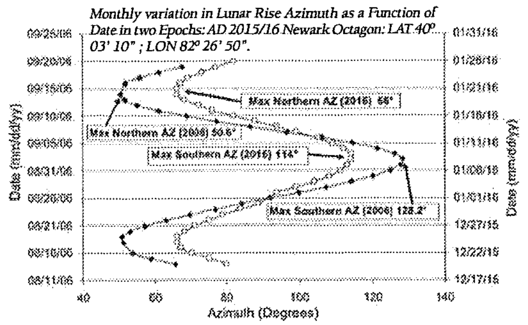

Fig. 3: Range of lunar rise azimuths for two epochs separated by 9.3 years.

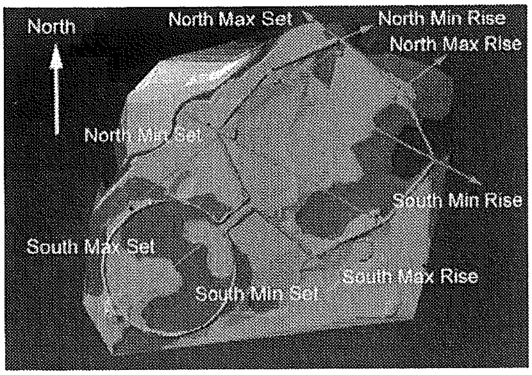

Fig. 4: Correspondence of the eight extreme rise and set azimuths with architectural features of the Newark Octagon.

made from Ohio's beautiful Flint Ridge flint are found scattered throughout eastern North America, but not in the quantities that would suggest a fair trade for the bushels of mica and copper found at Ohio Hopewell sites.

The Hopewell culture built many monumental ceremonial centers. There were, for example, major earthwork complexes at Marietta, Portsmouth, and near Cincinnati, Ohio; and nowhere was there a greater abundance and diversity of mounds and enclosures than along the Scioto River and Paint Creek valleys near Chillicothe. But the Newark Earthworks represent the grandest architectural achievement of the Hopewell.

The people of the Ohio Hopewell culture built one other octagonal earthwork linked to a circular enclosure. The High Bank Works is located along the Scioto River in Chillicothe. The circle has the same diameter as Newark's. The octagon, however, is much smaller. The High Bank Works' circle and octagon also incorporates alignments to the eight lunar rise and set points (Hively and Horn 1984). Moreover, the main axis of High Bank Works – that is, a line projected through the center of the circle and the octagon – bears a direct relationship to the axis of Newark's circle and octagon. Although built more than 97 kilometers apart, the axis of High Bank Works is oriented at precisely ninety degrees to that of Octagon Earthworks.

These connections of architecture, geometry, and astronomy suggest the people of Hopewellian Newark and Chillicothe had a close relationship. In this regard, it is interesting to note that the parallel walls that extended from Newark's Octagon to the southwest – and off the margins of every map of the Newark Earthworks – are on a course that would lead straight to Chillicothe. There is evidence to suggest this "Great Hopewell Road" was a ceremonial highway linking these two great centers of Hopewell culture (Lepper 2006). Perhaps it was a pilgrim's path like similarly long and straight roads built by the Mayan culture in Mesoamerica and the Anasazi of Chaco Canyon (Lepper 2006). Hopewell people may have followed this road, and perhaps others like it, to the great earthwork centers bringing offerings of copper or mica as gifts to the supernatural powers invoked by the monumental geometry of these sacred places.

The phenomena

Ray Hively and Robert Horn of Earlham College in Indiana set out to challenge the ideas behind the growing field of archaeoastronomy by demonstrating that one could pick any archaeological site with a sufficient number of linear walls and openings and find numerous astronomical alignments within the site. The prototype for their investigation was Stonehenge and the work of Gerald Hawkins (1965). They chose the Newark Earthworks as the site to investigate. Much to their surprise they did not find solar, planetary, or stellar alignments among the plethora of possible alignments in this very complex geometrical

Table. 1: *Table of Extreme Lunar Rise and Set Azimuths*

Lunar Extreme Rise or Set	Measured[a] Alignments	Elevation[a] Of Horizon	Calculated AD 200[b,c]	Calculated AD 2006[b,c]
N. Max Rise	52.0°	0.51°	51.1°	51.5°
N. Max Set	308.5°	1.70°	307.5°	307.2°
N. Min Rise	65.7°	0.36°	65.3°	65.8°
N. Min Set	293.4°	1.43°	293.5°	293.1°
S. Max Rise	130.3°	0.70°	129.8°	129.4°
S. Max Set	230.4°	0.49°	230.7°	231.1°
S. Min Rise	116.3°	0.86°	115.5°	115.2°
S. Min Set	244.3°	0.57°	245.1°	245.4°

[a]Reported by Hively and Horn (1982). [b]Refracted calculations using JPL Horizons Ephemeris available at http://ssd.jpl.nasa.gov/horizons.cgi, and MICA 2.0, developed by the USNO. [c]The obliquity and horizon elevation for the epoch taken into account.

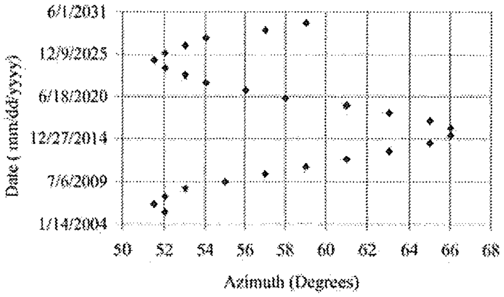

Fig. 5: *Maximum northern rise azimuth ca 2006 to 2030.*

arrangement of earthworks. Upon further investigation and analysis, they found that the Octagon-Circle complex did encode alignments which corresponded to the eight extreme rising and setting points along the horizon for the moon (Hively and Horn 1982). Research conducted later, uncovered similar alignments at the High Bank Works site mentioned earlier (Hively and Horn 1984).

As is well known, the moon's celestial path contains a number of simultaneous cycles. The 27.3-day sidereal period, the 29.5 synodic period a 173 day nutation period, and the much longer 18.61-year lunar regression period. Figure 3 shows the monthly azimuth of the rising moon at the Newark Octagon for two epochs, 2006 and 2016. These two eras, separated by 9.3 years, represent times when the declination of the moon varies between its extreme values. For the estimated time of construction ca 100 BC to AD 400, the obliquity of the ecliptic was approximately 23.67° (AD 200) and the extreme values of the declination of the moon ranged between ±28.82° and ±18.52° 9.3 years later. Current extremes of the declination vary between ±28.58° and 18.29° (AD 2000). This variation in declination occurs cyclically with the above mentioned 18.61 year period due to the regression of the lunar orbit. The eight extreme values of the rising and setting azimuths of the moon for the two epochs are given in Table 1. (**N. Max Rise** should be interpreted as: the Northern most azimuth of the rising moon when the declination of the moon attains its absolute maximum declination during the 18.61 year cycle. **S. Min Set** corresponds to the southernmost setting azimuth when the maximum southern declination is attained by the moon 9.3 years later). Correlation of the eight extreme rising and setting azimuths with architectural features of the Newark Octagon are displayed on the recent survey by A. Mickelson and M. Mickelson (Fig. 4) after Hively and Horn (1982).

Figure 5 is a plot of the northern most rising azimuth of the moon assuming no obstructing horizon and includes the effect of refraction during the 18.61 year lunar regression cycle at the Newark Octagon ca 2005 to 2030. An important point to be emphasized is that near the northern and southern standstills (when the moon approaches its maximum and minimum declinations), as with the sun, the azimuth varies slowly during these periods and thus

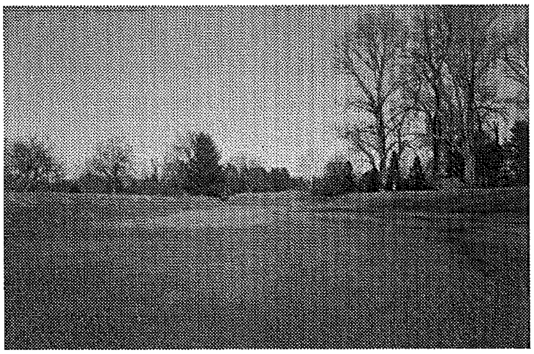

Fig. 6: *View along main axis toward the Northeast from entrance from the circle.*

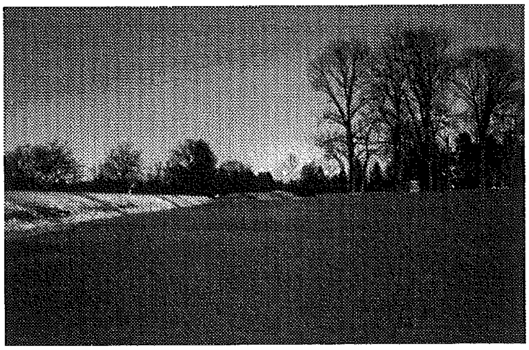

Fig. 7: *View of the moon rising along the main axis from position in Fig. 6.*

many near extreme risings and settings are observable for several years, month after month. The more obvious alignments occur after or near sunset however many are observable during daylight. Calculation of the rise, transit, and set azimuths of the moon using the JPL Horizons Ephemeris, for instance, shows that at least once, every sidereal month (and sometimes for two days) there is a close alignment with the main axis of the Newark Octagon which occur repeatedly from late in 2004 to well into 2007. The Horizons Ephemeris is available at http://ssd.jpl.nasa.gov/?horizons .

The observations

During the current epoch, the authors made numerous observations of the most northern moonrise at the Newark Earthworks from a vantage point along the main axis of the Octagon at a point where the parallel walls join the circle. Observations were attempted from the so-called Observatory Mound at the western most point of the main axis where it intersects the Octagon Circle (Figure 2). Trees and vegetation, however, prevented observation from this 10 meter high vantage point and the alternate location along the axis was used (Figures 2 and 6). Figure 6 shows a view from the observation point along the main axis at an azimuth of approximately 52 degrees in daylight. Photographs of the rising moon were taken from this position starting in October of 2004. Figure 7 shows a typical photo taken 16 December 2005 at 23:12 UT. The JPL Ephemeris predicted the moonrise at 22:43 UT at an azimuth of 51.8 degrees.

Conclusion

To date, the many observations of moonrises aligned with the Octagon strongly support the research of Hively and Horn (1982). Observations along other possible alignments are greatly hampered by the urban growth of the city and are not easily verified. The authors offer the following general conclusions:

1. Newark's Octagon Earthworks function successfully as a platform from which to view the northernmost rising of the moon as predicted by Hively and Horn (1982).

2. Apparently, knowledge of the 18.6-year lunar regression cycle was more widely appreciated by ancient peoples, including the Hopewell culture, than has been accepted by some researchers.

3. Developing this knowledge base must have encompassed a long period of time, particularly in regions such as the Ohio Valley where inclement weather often obscures the horizon. It is likely that knowledge of the phenomena was part of a cultural knowledge-base extending back for millennia.

4. The incorporation of lunar alignments in the design and construction of the Newark Octagon was conceived by an individual, or group of people, who had access to a substantial body of culturally-based knowledge relating to the alignments of the moon

throughout its 18.6-year cycle. These individuals were able to organize and carry out a monumental construction effort requiring great imagination and social organizational skills.

5. The 18.6-year lunar cycle has no practical application as, for example, an agricultural calendar. Therefore, fundamental aspects of the structure and function of the Newark Earthworks appear to be related to a ceremonial linkage between the monumental architecture and cosmological rhythms (Lepper 2004).

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