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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

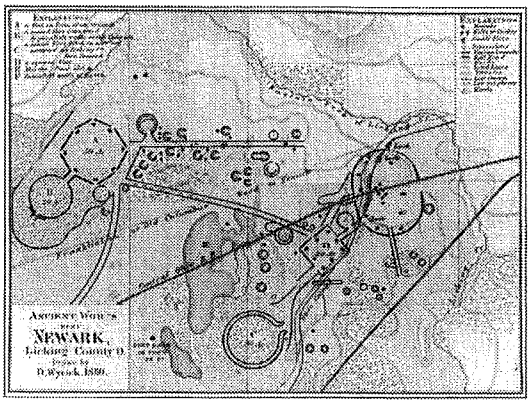

Fig. 1: *Wyrick map of the Newark Earthworks ca 1860.*

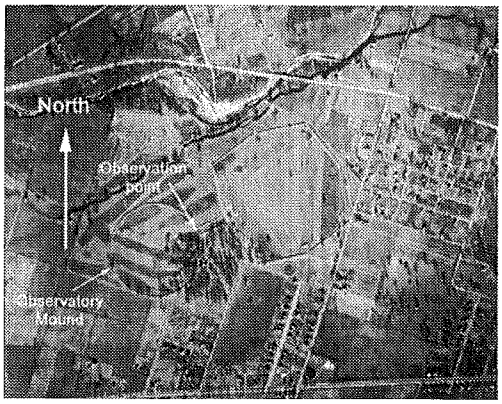

Fig. 2: *1934 Aerial view of existing Newark Earthworks, photo from National Anthropological Archives, the Smithsonian Institution, Washington, D.C., USA.*

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

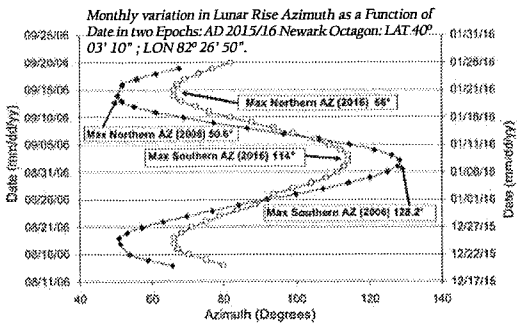

Fig. 3: *Range of lunar rise azimuths for two epochs separated by 9.3 years.*

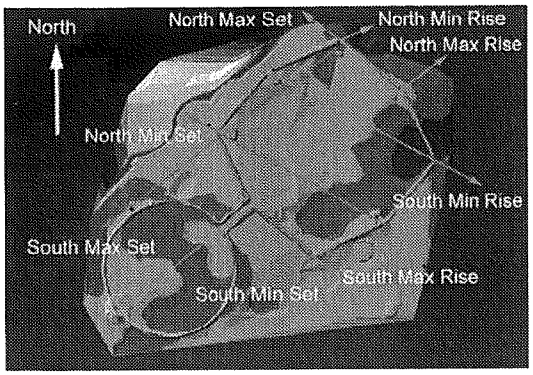

Fig. 4: *Correspondence of the eight extreme rise and set azimuths with architectural features of the Newark Octagon.*

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.

Maximum northern lunar rise azimuth for the 18.6 year lunar Regression Cycle ca 2006.

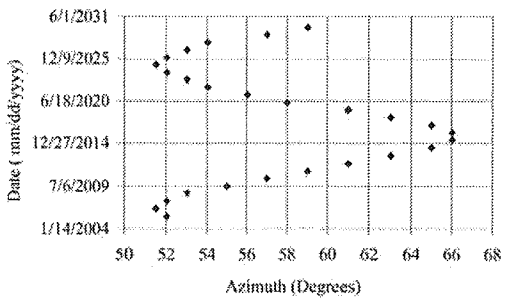

Fig. 5: *Maximum northern rise azimuth ca 2006 to 2030.*

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

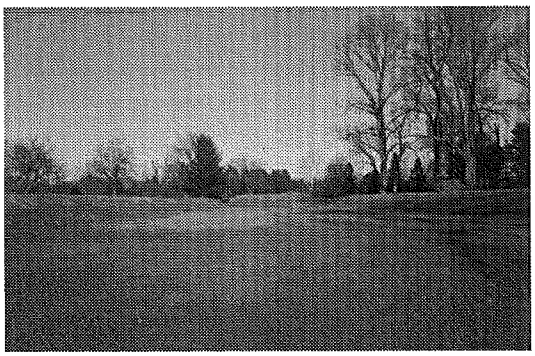

Fig. 6: View along main axis toward the Northeast from entrance from the circle.

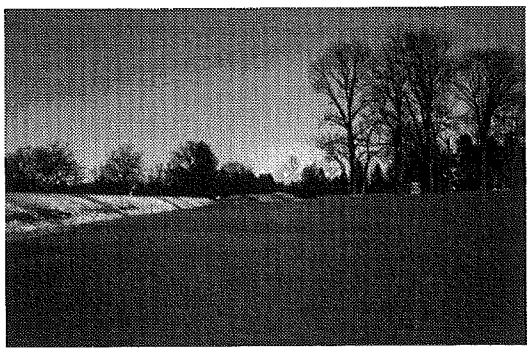

Fig. 7: View of the moon rising along the main axis from position in Fig. 6.

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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References

Hawkins, Gerald (1965) *Stonehenge Decoded*, Doubleday, New York.

Hively, R. and Horn R. (1982) Geometry and astronomy in prehistoric Ohio. *Archaeoastronomy* No.4 (JHA, xiii) S1-S20.

Hively, R. and Horn R. (1984) Hopewellian geometry and astronomy at High Bank. *Archaeoastronomy* No. 7 (JHA,) S85-S100.

Lepper, B. (1998) The Archaeology of the Newark Earthworks. In Sullivan, L and Mainfort, R (ed.), *Ancient Enclosures of the Eastern Woodlands*, University Press of Florida, Gainesville, 114-134.

Lepper, B. (2004) The Newark Earthworks: monumental geometry and astronomy at a Hopewellian pilgrimage center. In Townsend, R and Sharp, R (ed.), *Hero, Hawk, and Open Hand: American Indian art of the ancient Midwest and South*, The Art Institute of Chicago and Yale University Press, New Haven, 72-81.

Lepper, B. (2005) *Ohio Archaeology: an illustrated chronicle of Ohio's ancient American Indian cultures.* Orange Frazer Press, Wilmington, Ohio.

Lepper, B. (2006) The Great Hopewell Road and the role of the pilgrimage in the Hopewell Interaction sphere. In *Recreating Hopewell*, In Charles, D and Buikstra, J (ed.), University Press of Florida, Gainesville, 122-133.

Reeves, D. (1934) Dache M. Reeves Collection of Aerial Photographs, The National Anthropological Archives, Smithsonian Institution, Washington D.C., photograph no. 141 taken January 31, 1934.