Hopewell Archeology:
The Newsletter of Hopewell Archeology in the Ohio River Valley
Volume 6, Number 2, March 2005

2. Design and Layout of the Newark Earthwork Complex
By William F. Romain, Ph.D.

The Newark earthwork complex is the largest and most complicated geometric complex of its kind in the world. **(Figure 1)** shows the complex as represented by Squier and Davis (1848: Pl. XXV).

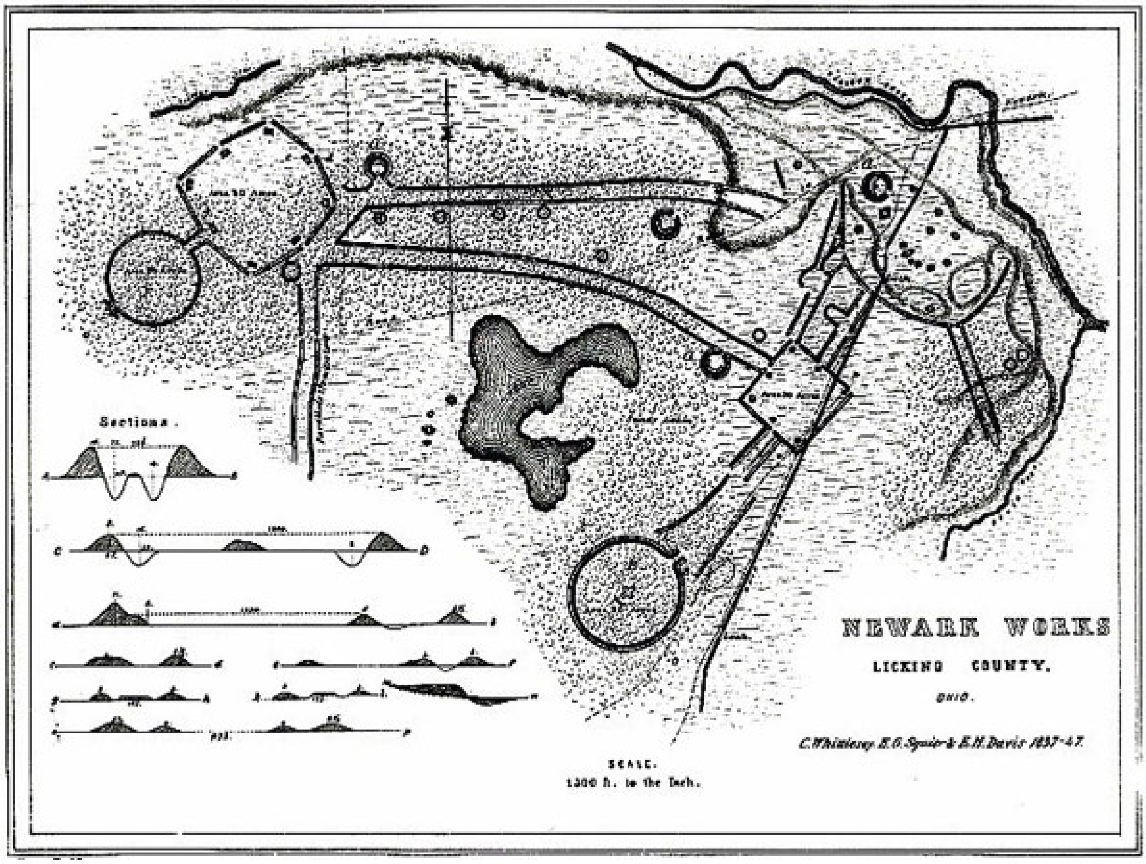

Figure 1. Squier and Davis's (1848: Pl. XXV) map showing the Newark earthwork complex.

(Figure 2) shows what remains of the complex today – i.e., the restored Octagon and Observatory Circle and the Great Circle. Also shown is Geller Hill. The likely location of the Great Hopewell Road (Lepper 1995) and Wright Square are also indicated, based on surviving remnants and aerial photographs (Reeves 1936).

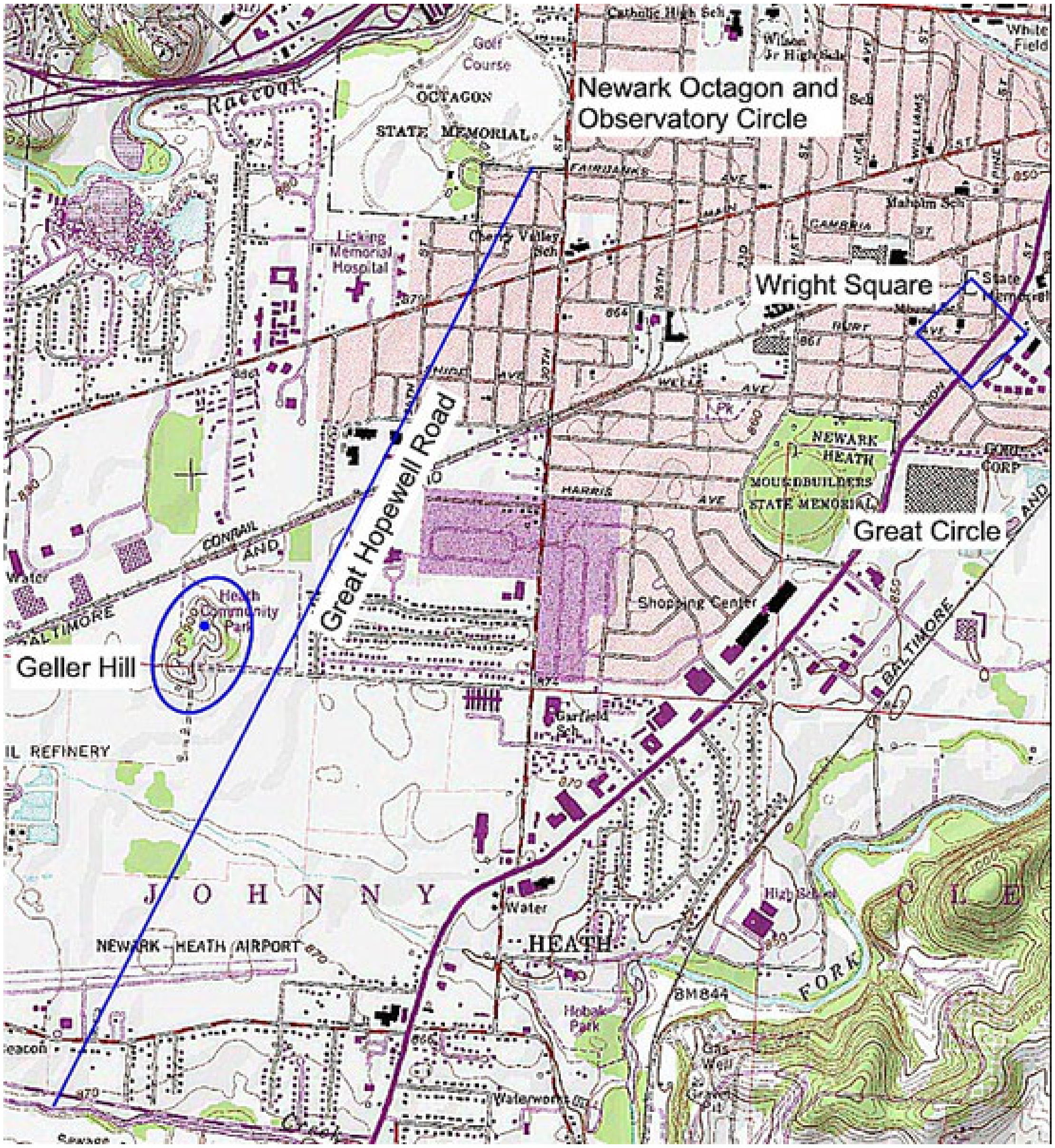

Figure 2. USGS 7.5-minute series topographic map showing part of the Newark earthwork complex. Wright Square and Great Hopewell Road drawn by the author based on information from aerial photographs and surviving remnants. (The oval earthwork and most of the parallel walkways shown on the Squier and Davis map are no longer visible.)

Looking at the Squier and Davis map, a casual observer might think that the large geometrically shaped earthworks, such as the Octagon, Great Circle, and Wright Square were arbitrarily located on the Newark landscape. As demonstrated below, this was not the case. Each earthwork is situated at precise coordinates and in a fashion that follows an internally consistent logic.

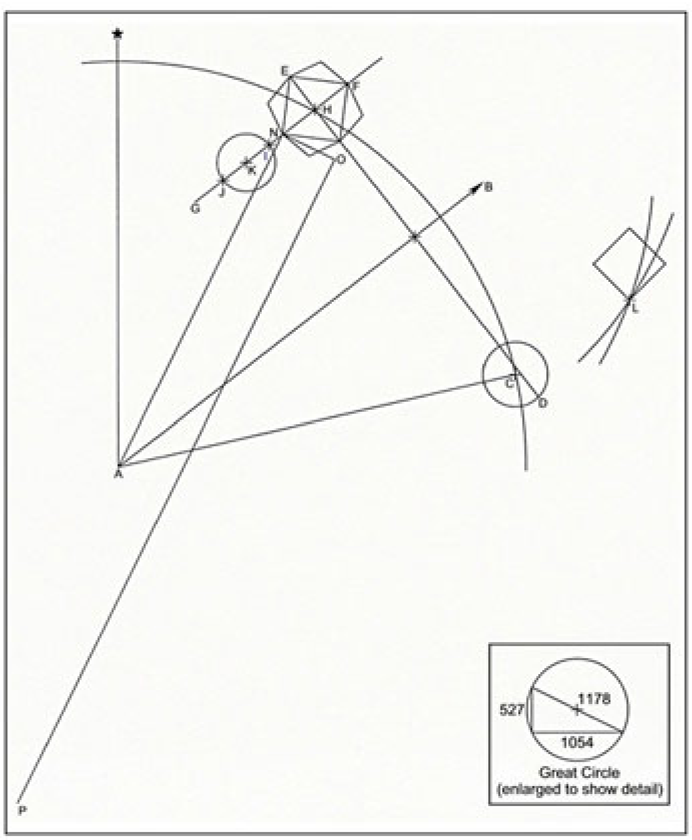

Figure 3. Schematic plan showing geometric and astronomic relationships among various features of the Newark earthwork complex.

With reference to **(figure 3, above)**, the following exercise shows how the Newark complex might have been designed and laid-out.

1. Point A is the apex of Geller Hill. Draw line A-B at an azimuth of 52°.2, which is equal to the moon's maximum north rise position as viewed from the top of Geller Hill (A.D. 100, lower limb tangency, apparent horizon elevation of 0°.5, corrected to 1°.34.)

2. Draw an arc having a radius of 7 OCD from point A. (One OCD is equal to 1,054 feet – which is the diameter of the Observatory Circle – see Hively and Horn 1982.)

3. Construct a circle having a diameter of 1,178 feet - equal to the size of the Great Circle. (Note that the diameter of 1,178 feet for the Great Circle is equal to the hypotenuse of a right triangle whose sides are equal to 1 OCD and ½ OCD, respectively.)

4. Draw line, D-E. Make line D-E, 7 OCDs in length. Situate line D-E so it is perpendicular to lunar azimuth line A-B, bisected by line A-B, and 589 feet from the 7 OCD radius line as measured along line A-B. The distance of 589 feet is one-half of the Great Circle diameter – which in step 3, was shown to derive from the OCD unit of length.

5. Position the center of the Great Circle on the 7 OCD radius line so its circumference meets line D-E at D.

6. At point E, construct a square having sides equal to 1 OCD. Orient the square so its diagonal falls on line D-E.

7. Construct an octagon around the square. Do this by drawing a series of arcs, each having a radius equal in length to the diagonal of the square. (Diagonal of square = 1,490 feet) Use each of the square's corners as the center for each arc. Connect the intersection points of the arcs by straight lines, thereby creating an octagon.

8. From Octagon point F, draw a line perpendicular to line D-E. Label this new line F-G. Line F-G is parallel to line A-B. Thus the Octagon is lunar-aligned. (See Hively and Horn [1982] for a further discussion of this lunar alignment.)

9. Locate the center of the Octagon and label it point H.

10. Locate points on line F-G that are 1 and 2 OCDs, respectively, from point H. Label these points, I and J.

11. Construct a circle on line F-G, using points I and J to establish its diameter. The diameter of the resulting circle will be 1 OCD - equal to the diameter of the Observatory Circle.

12. Establish the center of the Observatory Circle. Label the center of the Observatory Circle, point K. From point K, draw an arc having a radius of 7 OCDs.

13. Likewise, from point E on the Octagon, draw an arc having a radius of 7 OCDs. Mark the point where the two arcs intersect, point L.

14. Construct the Wright Square, oriented to the cardinal directions, using point L to situate the south corner of the Square. Note that each side of the Wright Square is 925 feet in length. This length is related to the OCD in the following manner. As mentioned, the diameter of the Great Circle is equal to the hypotenuse of a right triangle whose sides are 1 OCD and ½ OCD, respectively. The diameter of the Great Circle therefore is 1,178 feet. From this it follows that the circumference of the Great Circle is 3,700 feet. If the Great Circle circumference is divided by 4, the result is 925 feet. Thus, the 925-foot length is related to the OCD.

15. The azimuth and location of the Great Hopewell Road are established in the following way. From point A on Geller Hill, draw a line to point N on the Octagon. The azimuth of this line is 26°.2. From point N, draw a line 1 OCD in length perpendicular to line A-N. Mark the end of this line, point O. The reciprocal of 26°.2 (the azimuth of line A-N) is 206°.2. From point O, extend a line for a distance of 13,040 feet. along the azimuth of 206°.2. This line represents the length and azimuth of the Great Hopewell Road as far as Ramp Creek.

The above representations are idealized geometric constructions. The actual Newark earthworks vary in a few minor respects from the ideal – see **(figure 4)**. The Great Circle earthwork, for example, is not quite a perfect circle. Its diameter varies between 1,163 feet and 1,189 feet, for an average of 1,176 feet (Thomas 1894:462). So too, certain of the actual Octagon's walls vary from the geometric ideal in both length and azimuth - possibly to bring the walls in closer alignment with significant lunar positions. The azimuth of the major axis through the actual Octagon and Observatory Circle extends along an azimuth of 51°.8, while the geometric ideal, based on the moon's calculated azimuth is 52°.2 - for a difference of 0°.4. Thomas (1894:466) gives the lengths of the Wright Square walls as 926 and 928 feet – which differs by 1-3 feet from the geometric ideal of 925 feet. Also, the major axis of the Wright Square is skewed about 2° from the ideal, perhaps taking into account ground observations referenced to the distant horizon elevation.

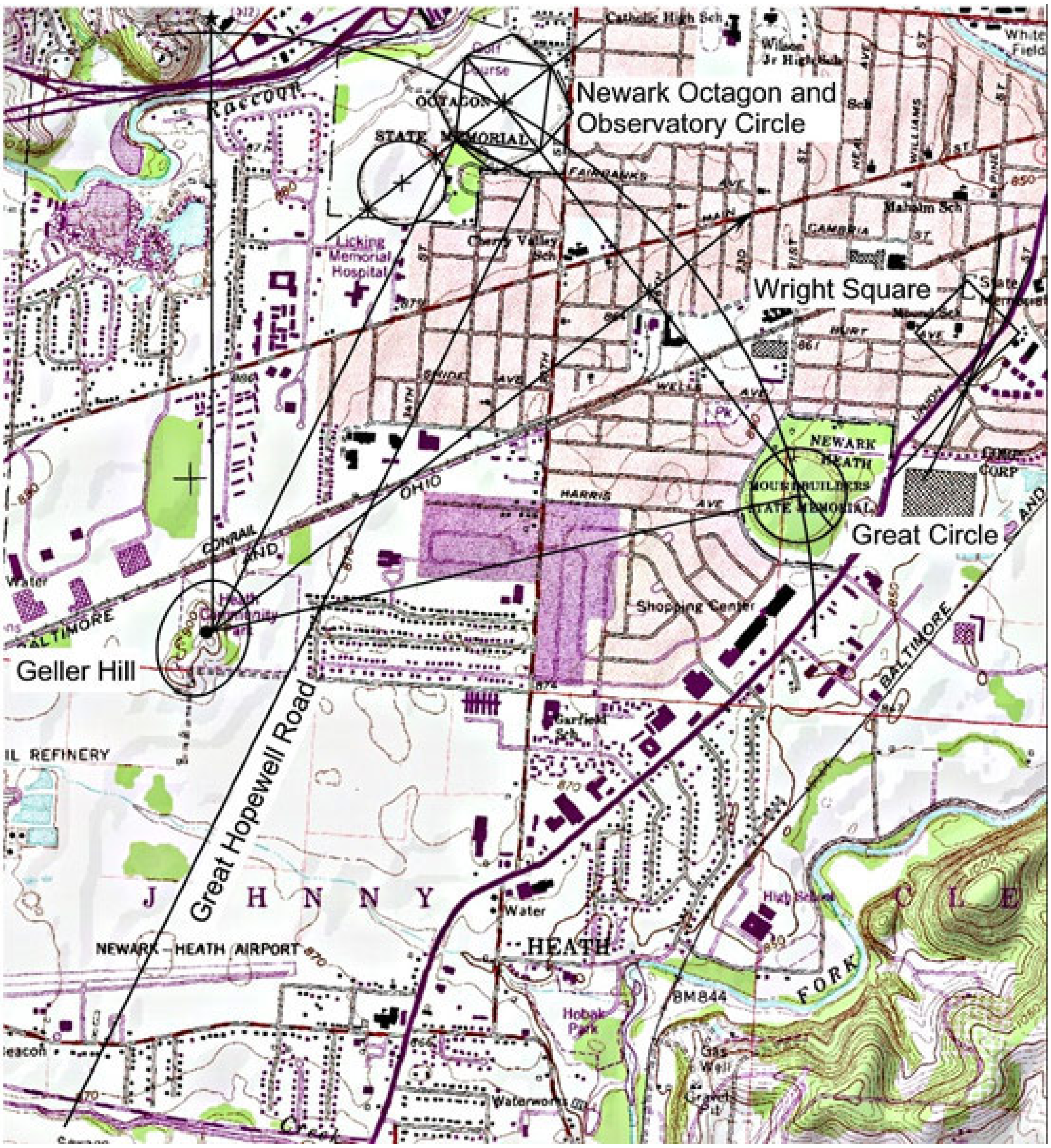

Figure 4. Ideal geometric design shown in figure 3 overlaid onto USGS 7.5-minute series map for the Newark area.

As for the Great Hopewell Road, remnants are still visible today at point O. These remnants are about 3 feet in height, extend for dozens of feet, and are located near the northeast walls of the Octagon. Sections of the south half of the Road can be identified in early aerial photographs (Reeves 1936). Reeves's (1936:fig. 4) representation of the Road, drawn based upon his aerial photographs, shows the Hopewell Road intersecting a modern-day road just south of the Newark-Heath airport. From these data, the azimuth of the actual Road can be plotted and is found to be 206°.9. This differs from the azimuth of 206°.2 for the geometrically plotted Road by 0°.7.

Several conclusions derive from this exercise:

1. The location of each earthwork is geometrically and astronomically related and dependent upon other earthwork components. Each earthwork is an integral part of a larger design.

2. The entire complex is, in effect, generated from Geller Hill – the suggested *axis mundi* for the Newark complex.

3. The complex was laid-out based on the moon's maximum north rise point and multiples of the OCD unit of length. The significance of the lunar maximum north rise for the Hopewell may have been based in the recognition that that event defines a temporal and spatial maximum in an 18.6-year cycle. Maximum nodes in any cycle imply a complementary opposite – to include, for example, a lunar maximum south rise. Notions of complementary opposites, bilateral symmetry, and cosmic dualism appear to have been important to the Hopewell and are expressed in a wide range of scales, from the structure of their earthworks, to designs incorporated in their artwork.

4. The most commonly used multiple unit of length was 7 OCD. Seven is considered an important number by many Native Americans. In Indian belief systems, the number 7 derives from the 4 cardinal directions, plus the center, zenith, and nadir.

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