Apéndice 5

DETERMINING THE ORIENTATION OF LE BASSIN MONUMENTAL DE BIBRACTE

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1. INTRODUCTION

On 21 July 1990, my colleague, Dr. Donna E. Swaim (D.E.S.)[1], and I (R.E.W.) visited the archaeological site on Mont Beuvray (the mountain was known to the Romans as "Bibracte", and was, in fact, visited once by Julius Caesar), near Autun, France. It is currently under investigation by the "Projet Internationale du Mont Beuvray". The visit was made as part of a longer journey we had made as co-leaders of a University of Arizona travel-group, visiting prehistoric sites of cultural and astronomical importance.

Our visit was made at the express invitation of a joint French/Spanish archaeological team led by Drs. Martin Almagro-Gorbea (A-G)[2] and Jean Gran-Aymerich (G-A)[3] because they have discovered a *bassin* they presumed was astronomicaly oriented. The ground orientation of *le bassin monumental* has been previously determined from the orientation of the archaeological grid system established by earlier investigations; the objective of the present work was to establish the relationship of the ground orientation of le *bassin* to the Horizon, or Alt-Azimuth, System of astronomical coordinates.

2. THE SITE, AND OBSERVATIONS MADE THEREFROM

Le bassin monumental is a low, lozenge-shaped or quasi-elliptical, masonry structure which appears to be a water collection basin; it is roughly 10.5 m. long in the major axis and 3.6 m. long in the minor axis. In the earlier publication (1989) by A-G and G-A, the orientation of *le bassin* was made relative to the grid system put in place by archaeological surveyors. From this work, they state that the long (major) axis of the elliptical basin is directed 34,5° East of Magnetic North.

A series of timed observations for magnetic bearing were made with use of a Brunton Pocket Transit, a very rugged and portable magnetic compass (± 2° reading error) and this author's own personal digital wristwatch (± 1s reading error). An independent log of the watch error was maintained throughout the whole, six-week long, journey, only a three-day portion of which was spent at Bourges and at Bibracte; the rate of the watch error was found to be rigorously linear over the six-week interval. As a result, the watch error on 21 July 1990 of observations was found to be 12.0 s FAST; all times of the observations were corrected accordingly.

Three separate obsevations for the magnetic bearing of the major axis of *le bassin* were made, looking generally from the SSW to the NNE; the average of the three observations was 39° with *nil* standard deviation as all three values were, fortuitously, the same.

Next, the magnetic bearing of the sun was observed at three different time intervals; the observational data is shown in the short table, below. The magnetic bearing of the shadow of the sighting post of the Brunton Compass cast by the sun was observed on the face of the compass itself while the compass rested levelly on the ground near *le bassin*. Such a technique results in a *back azimuth* actually being observed; the correct magnetic bearing is obtained by adding 180° to the back azimuth.

UT, 21 JULY 1990	*Mag. Bearing of sun*
14h 23.8m	244°
14 32.8	250°
14 41.8	256°

Table. The Timing and Magnetic Bearing Data for the sun at Bibracte

The geographic position of the site (LE = 6°22'32"[4]; = 46°55'37") is well known (A-G and G-A 1989); together with the individual times of the observations, the True Azimuth of the sun may be computed from the daily tabulations of apparent solar position in *The*

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[4] This value of the Longitude is with respect to the Prime Meridian at Greenwich; it has been derived from the value used by A-G (1989), which is relative to the Paris Meridian, and using L°(Paris)=2°20'14"E (*Astronomical Almanac* 1981, p. 129).

Astronomical Almanac 1990. The difference between the True Azimuth of the sun and its Magnetic Bearing at the same time gives a calibration of the amount of the so-called "magnetic deflection"; the mean value, and its standard error, for the three separate evaluations of the magnetic deflection value is as large as the evaluation itself, it is 2°6 ± 2°5 (True North is East of Magnetic North). While the standard error of the mean deflection value is consistent in its value with the estimated reading error of the magnetic compass.

The azimuthal orientation, then, of the major axis of *le bassin* is: 39° Mag. –2°.6 = 36°.4 True; consequently, the True Azimuth of the minor axis is 36°.4 + 90° = 126°.4. This value may be compared directly to the predicted value for the December Solstice sunrise point for a site with a flat astronomical ho-rizon at the same geographic position, i.e.: 125°.6 (figure 5.1). The difference between the two values, 0°.8, may be accounted for easily by the effect on the observed path of the sun by a low-lying hill in the line-of-sight to the sunrise point; having visited the site, there are abundant low hills in Oppidum's immediate neighborhood. If the hill is no more than three-quarters of a degree high, as seen from *le bassin*, the actual sunrise will be slightly delayed for a minute or so ... but the observed azimuth of the point of actual sunrise will be shifted by 0°.8 further towards the South. These apparent shifts are the result of the diurnal path of the sun being tilted to the Horizon by, roughly, 43° towards the South. The situation of a 10° mask occluding the true horizon has been illustrated in figure 5.2: the apparent rising point of the Sun (at the time of December Solstice) has been

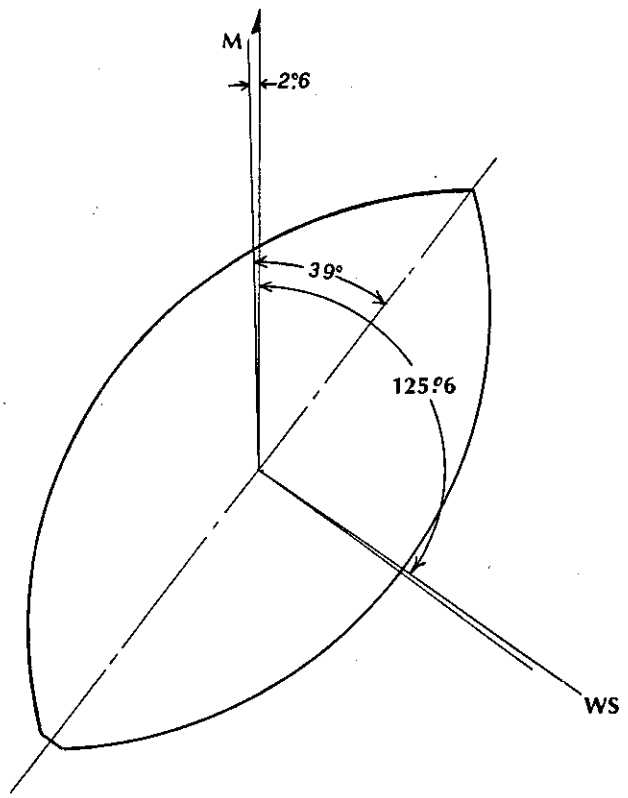

Fig. 5.1.—*Ground orientation of* le bassin monumental de Bibracte, *showing the deviation of True North from Magnetic North and the direction of the December Solstice rising sun (WS).*

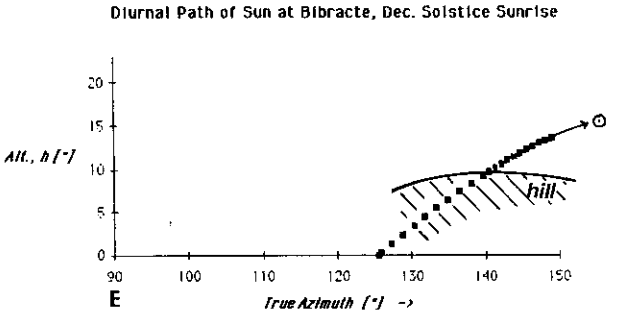

Fig. 5.2.—*Diurnal path of Sun at Bibracte. December Solstice Sunrise. The effect of an opaque mask ("hill") upon the perceived rising point of the sun at the latitude of Bibracte; the daily ("diurnal") path of the sun is shown as an interrupted set of filled squares when the sun is behind the mask, and a connected set of filled squares when it is well up above the mask. The abscissa is calibrated in tens of degrees of True Azimuth, from due East (E) at 90° to 150°.*

shifted southwards (towards greater values of the true Azimuth) by nearly 16° from the sun's rising point on the true hotizon. It is, therefore, imperative, that an accurate profile of the local horizon should be determined for the site. The problem facing the Bibracte archaeological work is that the area around the site has become heavily forested which blocks the view of the local horizon available to the Celts. Topographic maps of the area can be used, alternatively, to determine horizon profiles of sufficient accuracy for this phase of the work.

3. DISCUSSION

It is clear that the minor axis of *le bassin monumental de Bibracte* is oriented towards the local point of sunrise on the December Solstice, the most important day of the year for prehistoric agrarian populations and for use in their calendrics: the last day of the sun's journey to the South ... if all goes well!. For the early agrarian peoples, the daily raising and setting of the sun was not the phenomenon guaranteed by the Laws of Physics and Orbital Mechanics we take for granted today: each day was an affirmation of their trust in their gods.

Phenomena which we know, now, to be cyclic and governed by Physical Law were, by and large, perceived to be "accidental" occurences by the Ancients. Great uneasiness must have been generated amongst the general populace by the sun's annual excursion into the South: as it went further and further southwards, and the exterior temperature dropped lower and lower, the people must have become more and more anxious as the sun approached the December Solstice. The people must have wondered: would the sun turn around and head back northwards ... as it had always done before ... or, this time, continue its southerly journey into Eternal Night and freezing cold?. Imagine the relief when, each year, the sun stopped and then turned back northwards. "Magically", it would soon become warm again. It certainly would have been a fine excuse for a celebration!. The Roman *Saturnalia* were the celebratory feasts of the sun's ultimate return to the North, which were derived from the similar festivals of the Ancient

Greeks and dedicated to their god *Chronos* (the Romans' *Saturn*), the god of time.

It is equally clear that more precise observational techniques need to be brought into play at Bibracte: hand-held, even ground-supported, portable instruments don't have the necessary accuracy with which to make observational calibrations of magnetic deflections and attachments of local to astronomical coordinate systems. The difference of exactly 36,4 - 36,16 = 0,24° between the measured magnetic bearings of the long axis of the basin by A-G *(Apéndice 6)* and by this author is not significative. However, if orientation information about structures on site is to be gleaned from their relative alignments within the grid system, then abundant care must be taken to ensure that alignment errors of the entire grid are individually no worse than ±1'.

4. ACKNOWLEDGEMENTS

We, D.E.S. and R.E.W., thank Drs. Martin Almagro-Gorbea and Jean Gran-Aymerich for inviting us to participate in the activities at their research center at Bourges, and for permission - and encouragement - to visit the site of *le bassin monumental de Bibracte*; their logistical support to us while we were at Bourges is recalled here with great pleasure and appreciation.

REFERENCE

Almagro-Gorbea, M. and J. Gran-Aymerich, 1989, "Le bassin monumental du Mont Beuvray (Bibracte)", *Monuments et Mémoires de la Fondation Piot* 71, pp. 21-41.