ASTRONOMICAL ORIENTATION OF NEOLITHIC CIRCULAR DITCH SYSTEMS (KREISGRABENANLAGEN)

Georg Zotti
VIAS – Vienna Institute for Archaeological Science
University of Vienna – Austria

Abstract. Predating the famous megalithic stone rings of Great Britain by several millennia, Neolithic circular ditch systems (Kreisgrabenanlagen, KGA) have been built over a large region in Central Europe during a relatively short time span. Their entrances seem to have been frequently oriented towards astronomically relevant directions. Based on results of highly detailed geomagnetic surveys, an ongoing interdisciplinary research project tries to cast light on the possible astronomical connections of these early monumental structures.

1. Introduction

In the last decades, aerial photography has revealed several dozens of a certain class of Neolithic circular ditch systems, called Kreisgrabenanlagen (KGA), spread over a wide area of central Europe, from Hungary to westernmost Germany and Poland. Except for soil and crop marks, no traces of these structures remain visible in the topography of what is now mostly agricultural area. After discovery, geomagnetic surveys provide an excellent, fast way of recording their detailed shape (Melichar and Neubauer, 2010). Costly excavations can thus be targeted at the most interesting parts of the KGA, e.g. entrance areas. Unfortunately, evoked by intensive agricultural use of the soil, erosion has caused considerable damage, and only the deepest parts of the former ditches are still detectable.

KGAs typically consisted of up to three circular, V-shaped ditches with mean diameters of 70–110m and several metres depth, combined with up to three concentric palisades (Figure 1). Gaps ("doors") in the palisades usually were aligned with interruptions in the ditches. Radiocarbon dating has revealed that all KGAs date from the short time span from about 4850/4800 to 4550/4500 BC. The area of distribution spans several Neolithic cultural groups, so KGAs appear to represent an early transcultural idea (Trnka 2005a). Usually, they are free of buildings in the interior, but they were an integral part of a settlement. Their true purpose has been under discussion for decades.

Since the 1990s, view directions from the KGA centres through the entrances have frequently been interpreted in connection with sunrise or sunset positions

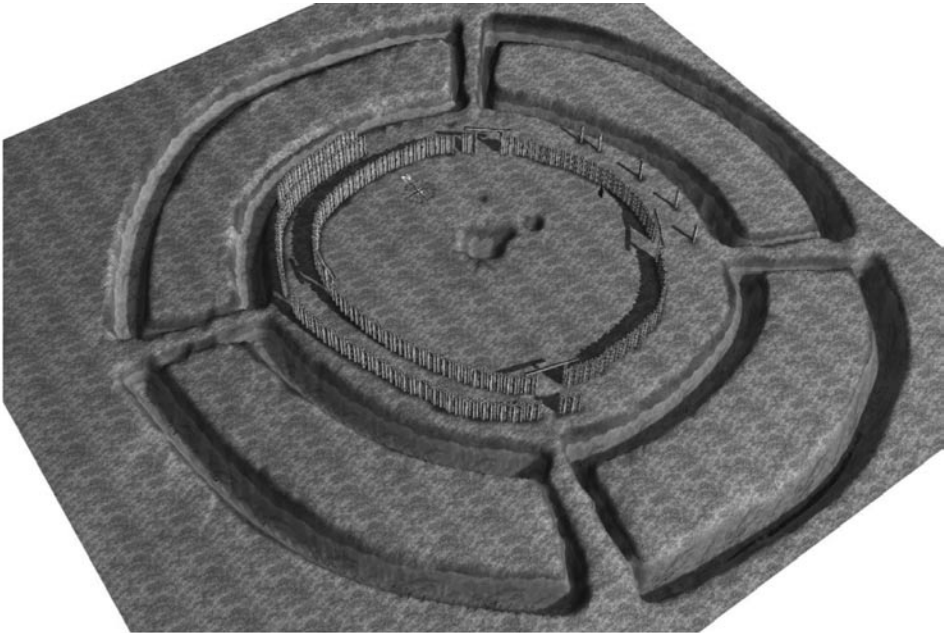

Fig. 1. Virtual reconstruction of KGA Steinabrunn, Lower Austria. The reconstruction only shows parts still detected in a geomagnetic survey, the outer palisade ring may have been complete as well. (Image: VIAS and Imagination, Vienna)

at the solstices and equinoxes (see e.g. Becker, 1996, Bertemes and Schlosser, 2004), or with lunar standstill events (Pavúk and Karlovský, 2004; Here, views from door to door are proposed.), and so KGAs are often popularized as "observatories".

The author was invited in 2003 to perform interdisciplinary research on the KGAs in Austria during preparation of the first large public exhibition on KGAs in 2005 (Daim and Neubauer, 2005). This investigation allowed a first overview of possible astronomical uses for many of the over 40 KGAs known in Lower Austria, the centre of their European distribution.

2. Astronomical orientation Studies

"Classical" archaeoastronomy in Europe is still heavily influenced by the pioneering work of Alexander Thom on the Megalithic stone rings of Great Britain (e.g., Thom, 1967), although his purported highprecision alignments of stone rings (Thom and Thom, 1978) have been largely rejected and can be explained as results of biased data selection (Ruggles, 1999, Ch. 2).

Still, an overall trend of low-precision orientation of building main axes towards astronomically significant directions remains visible in many prehistoric monuments. The horizon directions that are usually discussed are those towards rising and setting of the sun at the solstices, equinoxes (with considerable doubt expressed by Ruggles (1999, p. 150f)), and the "mid-quarter dates" just between the solstices and equinoxes, falling to early November/February and early May/August in our modern calendar. The latter are also frequently called "Celtic festivals" and given their (modernized) Celtic names, although many details of the Celtic calendar are still unclear, and most of the earlier claims of alignments may nowadays seem weak (Ruggles, 1999, p. 142). Of course, any direct connection between Neolithic "key dates" – if they were observed – and "Celtic" festivals should be rejected as pure speculation. Until today, however, these dates remain in the Christian calendar as Candlemas, May Day, or All-Saints' Day.

In addition, the lunar "standstill directions" are frequently quoted as important, i.e., northernmost or southernmost directions where a winter or summer full moon can be observed to rise or set. Due to the 5° inclination of the moon's orbit against the ecliptic plane and the 18.6-year revolution of this orbital plane, these rising and setting directions swing around the solstitial directions and show northernmost and southernmost extremes.

3. A New Diagram

For the investigation of the Austrian KGAs, a new diagram was developed, combining an archaeological interpretation map drawn from the results of the geomagnetic surveys (Trnka 2005b), a horizon line gained from a digital elevation model (DEM; where available), and a representation of a sky map folded "outward", showing the tracks of the sun on the 8 mentioned key dates, the moon at the standstill declinations, and diurnal tracks of stars for the epoch -4700 (Zotti, 2006; Figure 2). The observer is located in the centre of the diagram, looking outward. Such an azimuthal chart appeared to be an optimal tool for a rapid investigation and identification of celestial objects that may have been targeted from a single location, i.e., the KGA centre.

The first idea was that always the centre of the KGA was the observing location, and that all entrance axes meet in the centre. However, at the best-preserved KGAs, the directions of entrance axes and radial ditches still visible do not meet in a single central point, but rather in a small area, hinting at the possibility of non-central observations. By shifting the diagram over the KGA map, it is pos-

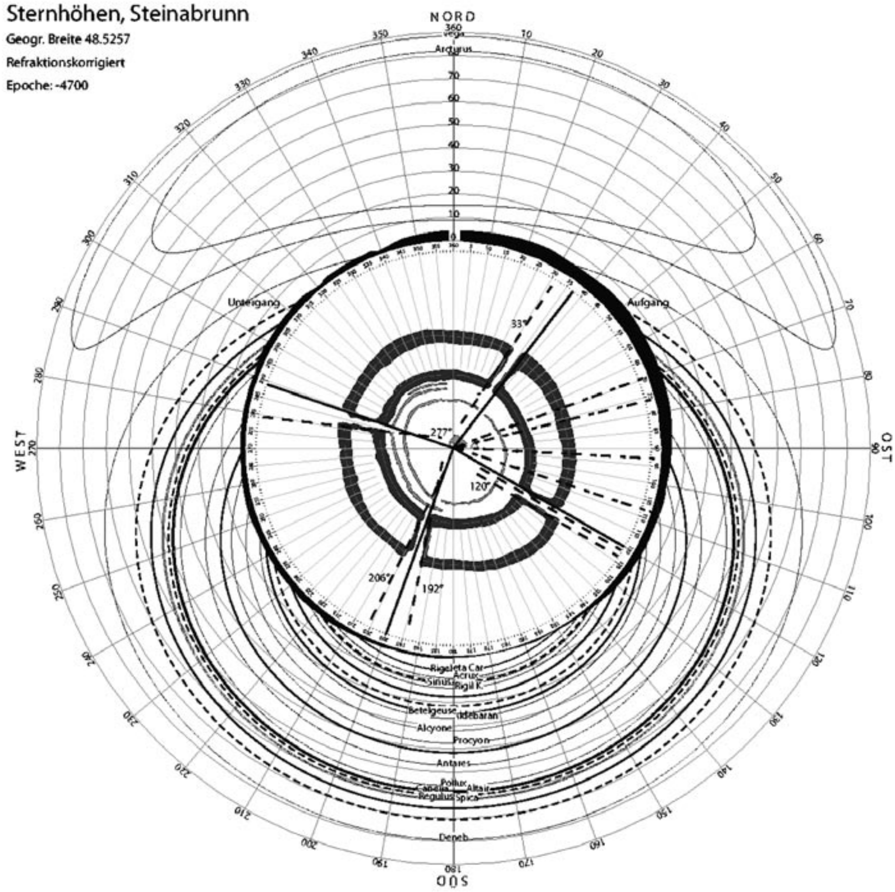

Fig. 2. KGA map for Steinabrunn surrounded with an astronomicaldiagram showing horizon and tracks of sun (5 strong lines for solstices, equinox and mid-quarter days), moon (4 strong dashed lines for the standstill declinations) and stars (Zotti, 2008).

sible to locate meaningful observing locations, so that, e.g., a view falls parallel to a radial ditch. The error in horizon elevation (without recalculating the horizon for the new location) would be reasonably small as long as it is not too close.

Given that all Austrian KGAs fall within about ½° of geographic latitude, it is permissible to collect all azimuth data into a histogram under a common sky (Figure 3), so that azimuth directions more frequently occurring in the KGAs should form readily detectable groups. Of course, without mapping horizon data into this version of the diagram, groups will form near the "target" directions. Be-

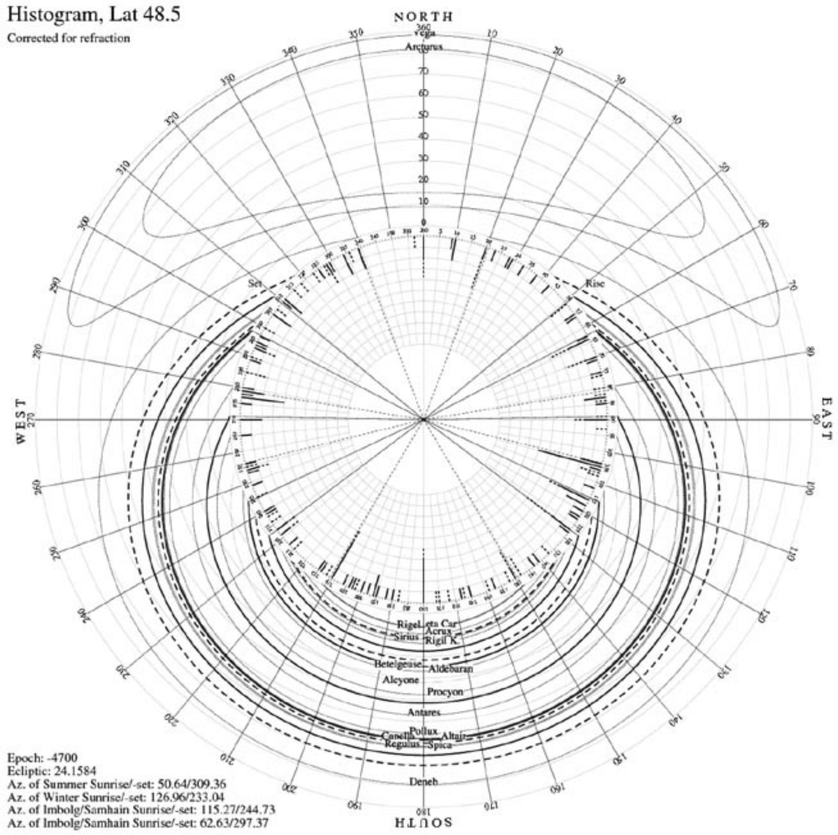

Fig. 3. A combination of all plausible azimuths of 27 KGAs. A circular histogram stretching from the “horizon” towards diagram centre shows the number of well-defined (stroked) and additional less-well defined (dotted) directions. The most distinct groups are south of 105° (rising Pleiades) and 279° (setting Antares).

cause any raised horizon (hill chain, ...) pushes both rising and setting azimuths southward, the groups are expected to be limited on the north side by the “target” direction on the mathematical horizon, and to extend southward from that by several degrees.

4. First Results

During collection of directions, many possible directions were entered into the histogram data, with the aim to enter the evaluation unbiased, *i.e.*, without preselecting only those near apparently interesting ones. Directions appearing meaningful were always entered as seen from KGA centre (1) towards earth bridge centrelines, (2) through gaps in the palisades and (3) to the limits of palisade ditches. Where KGAs with 2 ditch rings included radial ditches, these sharper directions were preferred over the less well defined radial earth-bridge directions. Certainly, some of the directions gathered are caused by "false limits", *e.g.,* where a palisade ditch nowadays ends due to erosion, and not because it (or the palisade) really ended there. Still, frequently observed directions should stand out from a "noise" of such false entries.

Based on previous results from the literature, it was expected to find an orientation preference for azimuths explainable as solar-oriented, *i.e.*, towards solstices and maybe the mid-quarter dates. Indeed, there appears to be a group of 3–6 (read: 3 clearly defined and 3 less certain) indications towards sunrise at winter solstice. 3–4 indications are visible towards the winter mid-quarter date (November/February), and 3–5 indications towards sunrise on the summer mid-quarter date (May/August). Only 2–4 indications point close to summer solstice sunrise. The sunset directions appear free of recognizable solar-related groups. In total it must however be said, about 2–6 "hits" for each of these 4 directions out of 27 investigated KGAs does not appear overwhelmingly convincing for calling all KGAs generally "solar temples" or similar (Becker, 1996), even if about every fifth of them may indeed have borne such demonstrable elements of practical astronomy.

Regarding the lunar standstill directions (strong dashed lines in Figures 2 and 3), no connection of centrally observed entrance azimuths towards these directions can be seen. However, entrance-to-entrance sight lines, as claimed for KGAs in Slovakia (Pavúk and Karlovský, 2004), have not been investigated so far.

However, there appear other and even stronger gatherings of indicated azimuths than those mentioned above for the "usual" solar directions. There are 4–5 directions "due south" and 2–5 "due north", hinting at a concept of cardinal orientation, and 4–5 towards azimuth 210°, where neither sun nor moon can set on a low horizon. If horizon astronomy should explain this direction, only stellar alignments seem possible. In addition, there are the two largest groups, south of 105° and south of 279°, which can be reached by the sun, but at no date of obvious significance. The short and well-known time span of only about 300 years for all KGAs allowed to compute the Neolithic starry sky and look for bright stars which could have been visible in the respective directions.

The result of this stellar evaluation brought the strongest surprise, however:

every third KGA showed one entrance oriented towards the rising of the Pleiades, most apparent of all open clusters, and another towards the setting of Antares. Entrances towards the northern horizon may be related to the star Deneb, which was the northernmost noncircumpolar bright star (Figure 4). Further, the Pleiades rose at about the same time as Antares was setting, and at this very moment Deneb was also culminating (Figure 5). In addition, when this view was replayed in a planetarium (Zotti et al., 2006), the Milky Way spanning the sky added another element of intriguing beauty to this scene.

Was this a "sacred moment"? Were these 3 objects used as time-keepers or "calendar stars"? We will never know for sure, but for an archaeoastronomer, yet another event adds hugely to the excitement: the heliacal rising of the Pleiades in that period happened only a few days after spring equinox! Systematic observation of the heliacal rising of the Pleiades could have been used in some connection to the agricultural year, even if seeding time should have been over this date. The setting of Antares would act as "herald" to the morning twilight rising of the Pleiades in this scenario. Together with the solar orientations, this provides calendrical uses as one possible aspect of many of these huge monuments. Regarding the azimuth 210°, Rigel was setting there as only bright star of today, but a connection to the 3 mentioned stars has yet to be found. Thinking wider,

Fig. 4. Deneb rising on the elevated landscape horizon as seen through a gap left of the north-east entrance in the palisade, in the direction of a radial ditch, at Steinabrunn.

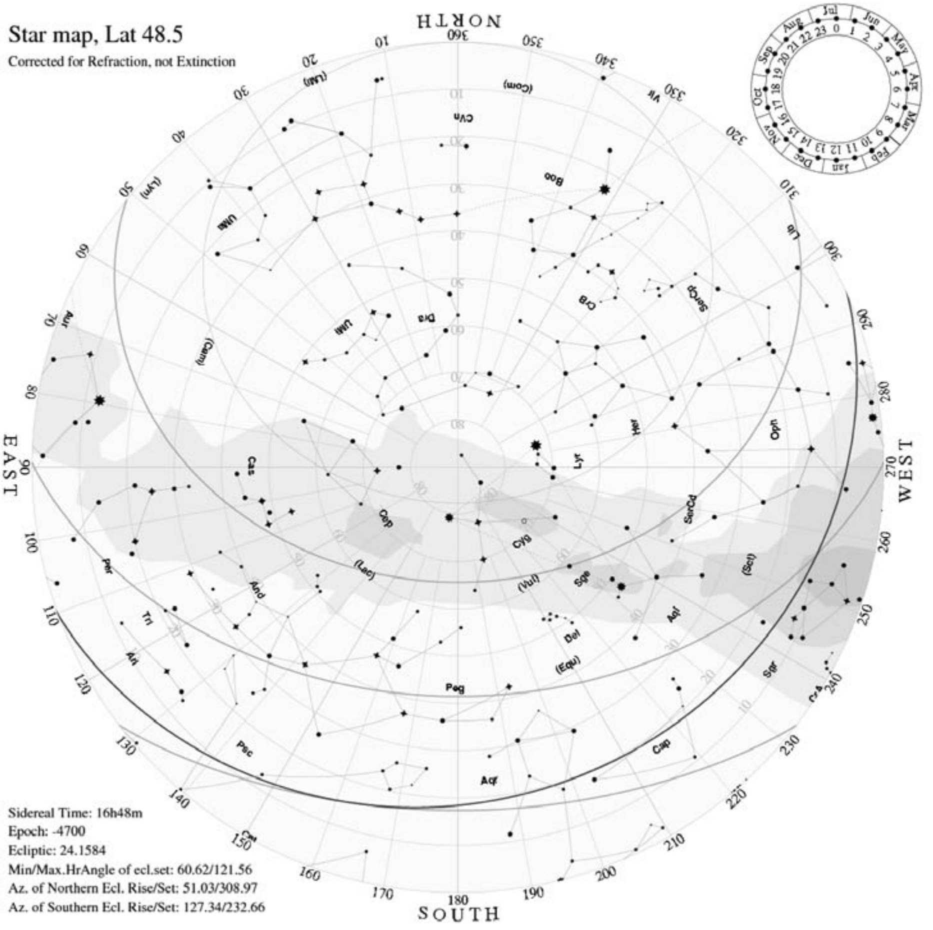

Fig. 5. View of the Neolithic sky with Antares setting (near 279°), Pleiades rising (105°) and Deneb culminating.

Eta Carinae could also explain the same azimuth – if this luminous blue variable only was hugely brighter 6800 years ago!

These preliminary results (Zotti, 2010), gained from GIS and DEM horizon data only, are at least noteworthy and seem to indicate a strong astronomical element in the architecture of many KGAs. The fact that not all KGAs show astronomical alignments is however a likewise strong indication that astronomy was not generally their most important use.

5. Ongoing Research

Most of the Austrian KGAs have already been magnetically surveyed, providing a huge high-quality archaeological resource that would allow more extended astronomical analysis. A new research project is now supported by the Austrian Science Fund (FWF, project P21208-G19, "ASTROSIM: Simulation of astronomical aspects of Middle Neolithic circular ditch systems"). It continues where the first investigation had to stop, and shall bring more certainty into the hypotheses. First and foremost, the present surveys lack horizon survey data. So, all KGA sites in Austria have to be visited by the astronomer, also in order to experience the landscape, the interplay of near and far horizons, terrain slope, possible effects of vegetation, etc. All these considerations were not possible from the sketches available in the previous investigation. There are still many archaeological questions open regarding KGAs and their placement in the landscape, and selecting the building sites considering astronomical aspects like the visibility and direction of peculiar horizon marks may have been one of them. During these visits, the complete horizon is surveyed with a total station for each KGA centre, and a photographic panorama is taken, later to be carefully fit to the measured horizon line. From the panorama, combined with an astronomical diagram showing star tracks and declinations, correct declinations can be read for each palisade or ditch azimuth for an unbiased evaluation. Such a panorama can also be used directly inside desktop planetarium software for simulations.

Results from the surveys shall also be compared to "desktop results" gained with GIS and digital elevation models, so that the validity of such a "purely digital" approach can be better estimated. From the first visits it is however already obvious that field work remains essential, as small errors in DEM elevations, or even interpolation artefacts by DEM coarseness, can yield large differences in observed altitude, if the visible terrain is close. Further, a larger number of KGAs shall be virtually reconstructed in its landscape to allow a virtual walkthrough and maybe better estimate views of astronomical significance.

References

Becker, Helmut, *Kultplätze, Sonnentempel und Kalenderbauten aus dem 5, Jahrtausend vor Chr. – Die mittelneolithischen Kreisanlagen,* in Niederbayern, ARBEITSHEFTE DES BAYRISCHEN LANDESAMTES FÜR DENKMALPFLEGE, **59**, 1996.

Bertemes, François; Schlosser, Wolfhard, *Der Kreisgraben von Goseck und seine astronomischen Bezüge,* in Meller, Harald (ed.), *Der Geschmiedete Himmel – Die weite Welt im Herzen Europas vor 3600 Jahren*, Theiss Verlag, 2004, pp. 48-51.

Daim, Falko; Neubauer, Wolfgang (editors), *Geheimnisvolle Kreisgräben iederösterreichische Landesausstellung 2005*, Horn, Wien, Verlag Berger, 2005 (Exhibition Catalog).

Melichar, Peter; Neubauer, Wolfgang, *Mittelneolithische Kreisgrabenanlagen in Niederösterreich. Geophysikalisch-archäologische Prospektion – ein interdisziplinäres Forschungsprojekt*, Mitteilungen der prähistorischen Kommission der Österreichischen Akademie der Wissenschaften, 2010.

Pavúk, Juraj; Karlovský, Vladimír, *Orientacia Rondelov Lengyelskej Kultury na Smery Vysokeho a Nizkeho Mesiaca* (*Orientation of Lengyel rondels to directions of High and Low Moon*), Slovenská Archeológia, vol. LII(2), 2004, pp. 211-280.

Ruggles, Clive, *Astronomy in Prehistoric Britain and Ireland,* New Haven and London, Yale University Press, 1999.

Thom, Alexander, *Megalithic Sites in Britain*, Oxford, Clarendon Press, 1967.

Thom, Alexander; Thom, Alexander S., *Megalithic Remains in Britain and Brittany*, Oxford, Clarendon Press, 1978.

Trnka, Gerhard, *Kreise und Kulturen – Kreisgrabenanlagen in Mitteleuropa*, in Daim and Neubauer 2005, 2005a, pp. 10-18.

Trnka, Gerhard, *Katalog der mittelneolithischen Kreisgrabenanlagen*, in Daim and Neubauer 2005, 2005b, pp. 244-247.

Zotti, Georg, *Kalenderbauten? Zur astronomischen Ausrichtung der Kreisgrabenanlagen in Niederösterreich*, in Daim and Neubauer, 2005, pp. 75-79.

Zotti, Georg, *A Sky Dome visualisation for identification of astronomical orientations*, Information Visualization, **5**, 2006, pp. 152-166.

Zotti, Georg; Wilkie, Alexander; Purgathofer, Werner, *Using Virtual Reconstructions in a Planetarium for Demonstrations in Archaeo-Astronomy*, in Cecilia Sik Lanyi (ed.), *Third Central European Multimedia and Virtual Reality Conference* (Proc. CEMVRC2006), Pannonian Univ. Press, 2006, pp. 43–51.

Zotti, Georg, *Zur astronomischen Interpretation ausgezeichneter Richtungen der Kreisgrabenanlagen Niederösterreichs*, in Wilfried Menghin (ed.), *Acta Praehistorica et Archaeologica*, 40. Museum f. Vor- und Frühgeschichte, Berlin, 2008, pp. 61–67.

Zotti, Georg, *Astronomische Aspekte der Kreisgrabenanlagen in Niederösterreich*, in Melichar and Neubauer, 2010, pp. 136–167.