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KREISGRABENANLAGEN: EXPRESSIONS OF POWER LINKED TO THE SKY

GEORG ZOTTI, WOLFGANG NEUBAUER

Abstract: Several archaeologically distinct cultural groups developed a certain class of monumental structures in a rather short period during the Middle Neolithic in Central Europe: *Kreisgrabenanlagen* (KGA; a form of circular enclosures). The astronomical orientation of the entrances into these monuments has been discussed for many years. In a new project we analyze and simulate astronomical aspects for the KGAs in Lower Austria. This work combines previous archaeological surveys by magnetic prospection, excavation results, on-site horizon measurements, virtual reconstruction and astronomical simulation software.

Keywords: Kreisgrabenanlagen, orientation studies, horizon survey, virtual reconstructions

In a short period (ca. 4850/4800-4550/4500 BC) of the Middle Neolithic, a certain class of circular monumental ditch systems, *Kreisgrabenanlagen* (KGA), was built in many places in Central Europe. They have been detected by aerial archaeology in Hungary, Slovakia, Czech Republic, Austria, Germany, and Poland (Figure 1).

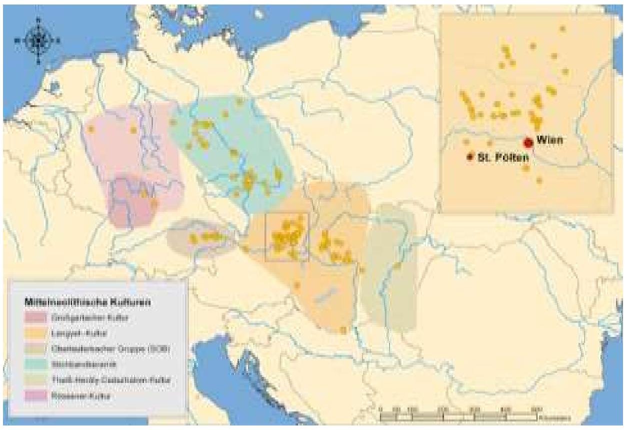

Figure 1. Distribution of Kreisgrabenanlagen and the respective Neolithic cultures. (Daim and Neubauer 2005)

The Austrian monuments are characterized by up to four concentric circular V-shaped ditches with diameters typically ranging from 45 to 180 m, up to four internal wooden palisades, and at least two opposed entrances. They were an integral but separated part of the associated Middle Neolithic settlements indicating a central-place role with no obvious defensive function. The most likely explanation is their use as some form of ritual place, a place for gatherings, or for certain ceremonies. The area of their distribution spans several archaeologically defined Neolithic cultural groups, so they appear to represent an early transcultural idea (Trnka 2005a).

Nothing remains visible in today's topography. The structures are typically discovered by aerial photography, where they appear as soil and crop marks. Magnetic prospection has become the method of choice to gain a fast, but still reliable survey for the large areas, when excavation is too costly (Figure 2).

Astronomical Aspects of *Kreisgrabenanlagen*

It can be frequently shown that the azimuths of the entrances, as seen from the centre, are identical to certain important rising or setting solar azimuths in the course of the solar year (e.g. solstices) (Becker 1996; Iwaniszewski 1996; Bertemes and Schlosser 2004). On the other hand, several KGAs in Slovakia have been associated with lunar standstill orientations (Pavúk and Karlowský 2004).

A typical problem of previously published studies analyzing the azimuth orientations of entrances or palisade gaps, is the lack of horizon data and therefore lack of accurate declinations, which may lead to wrong associations of celestial bodies, especially in cases where horizon altitude is significant. Also, the published maps usually suggest flat terrain to researchers who may not have a chance to visit the sites themselves.

About 40 KGAs are known in Austria, and most of them have been magnetically surveyed since the 1990s (Melichar and Neubauer 2010). A first investigation of these data supported the idea of solar orientation of several entrances, but also indicated that some azimuths – within and outside the range of solar azimuths – may also be explained by stellar orientation (Zotti 2008, 2010a).

These results invite the idea of a calendrical use as one further aspect of KGAs. The observation of sunrises and sunsets on certain dates like the cross-quarter days (dates just between solstices and equinoxes, i.e., approximately early November/February as begin/end of a solstice-centred "Winter" season, and early May/August as begin/end of a solstice-centred "Summer" season) in the course of the year, or heliacal risings or settings of certain stars in that period, may have been linked to processes on Earth, like begin and end of the agricultural year, or festivals related to livestock breeding. However, this first

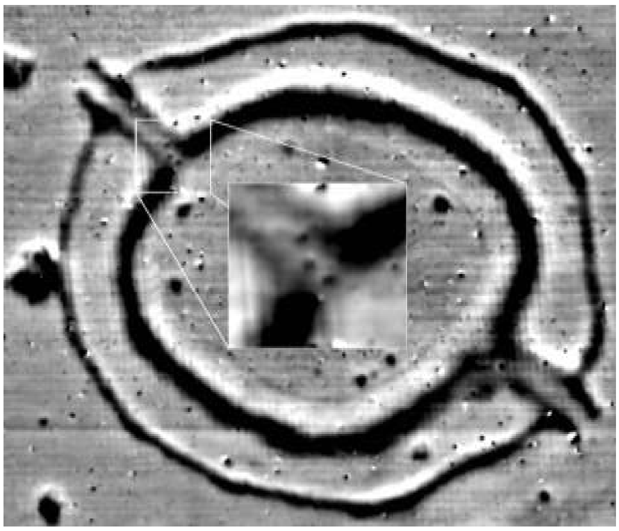

Figure 2. Magnetogram of KGA Pranhartsberg 2. The double ditches are far from perfect circles, and the entrance axes formed by the passages do not intersect close to the KGA's center. In the northwest entrance just in-line with the main ditch, two magnetic anomalies may indicate postholes pointing towards summer solstice sunset (see also Figure 7).

study was based on flat archaeological interpretation maps without consideration of local topography, and horizon altitudes were only derived from digital elevation models, not based on field measurements.

Kreisgrabenanlagen as expressions of Power

We can only vaguely guess the state of beliefs of the KGA builders. Clearly, a whole group of people had to work together under the command of a main architect. The creation of astronomically motivated entrances required knowledge about and systematic observation of celestial phenomena as well as the power over a sufficiently large population – a power which may have linked the celestial processes with earthly authority. The astronomical aspects indicate that the monuments had a calendrical function and were probably associated with ritual and festive events. They might have been used for the legitimation of cultural or social habits through natural phenomena. Because these social patterns required such dramatic support, it may be supposed that they were novel. It is reasonable to assume the KGAs functioned in part in the legitimation of territorial ownership by new social groups and non-local traditions. That is, the ritual or functional idea behind the KGAs, or their expression of the power and might of individuals or groups, may have played a vital role for the formation of new cultural and/or political identities (Timothy Taylor, pers. comm.).

Surveying and Modelling of *Kreisgrabenanlagen*

The existing archaeological data consist mostly of georeferenced geomagnetic surveys and archaeological interpretation maps which show the outline of the filled ditches and palisades, and results from excavations where available. Typically, archaeological excavation reports or magnetograms show 2D maps or lists of orientation azimuths neglecting the visible horizon and the specific topographic situation of the respective site. The recently published overview of the Austrian KGAs (Melichar and Neubauer 2010) includes topographical information, but no horizon data. In our current project (ASTROSIM), we investigate the potential astronomical orientations in much more detail than was previously possible (Zotti 2010b).

For the astronomical investigation of the KGAs in Lower Austria, we have re-visited all 33 sites where magnetic data is available with a total station to add a survey of horizon altitudes, on which an aligned photographic horizon panorama is carefully fitted. These panoramas, now fitting the surveyed line to within 1-2 arcminutes, are combined with latitude-dependent diagrams showing

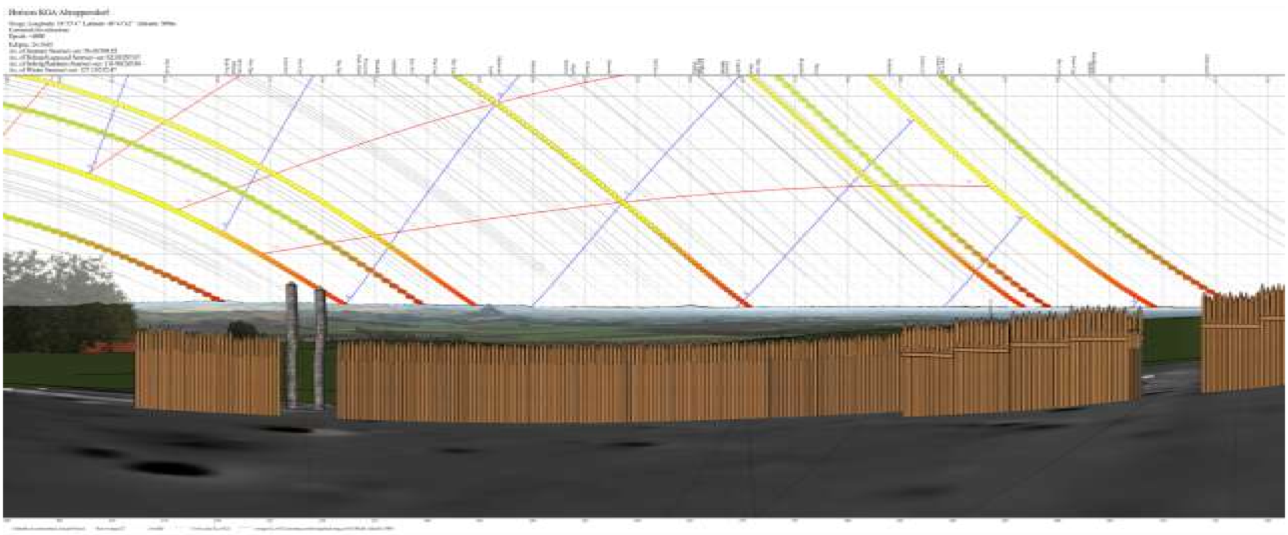

Figure 3. Part of the horizon panorama of KGA Altruppersdorf. This site overlooks a distant south horizon (partially blocked by a nearby tree, in the left edge of this part), the terrain slopes upwards towards north. A conspicuous hill (left of center), visible even from inside the KGA if the palisade (reconstructed here) was not excessively high, almost coincides with winter cross-quarter sunset (chain of sun circles). A lack of such landmarks at other sites however suggests a coincidental alignment.

Figure 4. The surveyed horizon line is completed with a carefully adjusted panorama photograph and astronomical diagram of diurnal tracks. These panoramas show the frequently elevated horizon, current treelines and buildings (Rosenburg is near center in this case), and can be directly evaluated, but also used as background in virtual reconstructions and in appropriate astronomical simulation software.

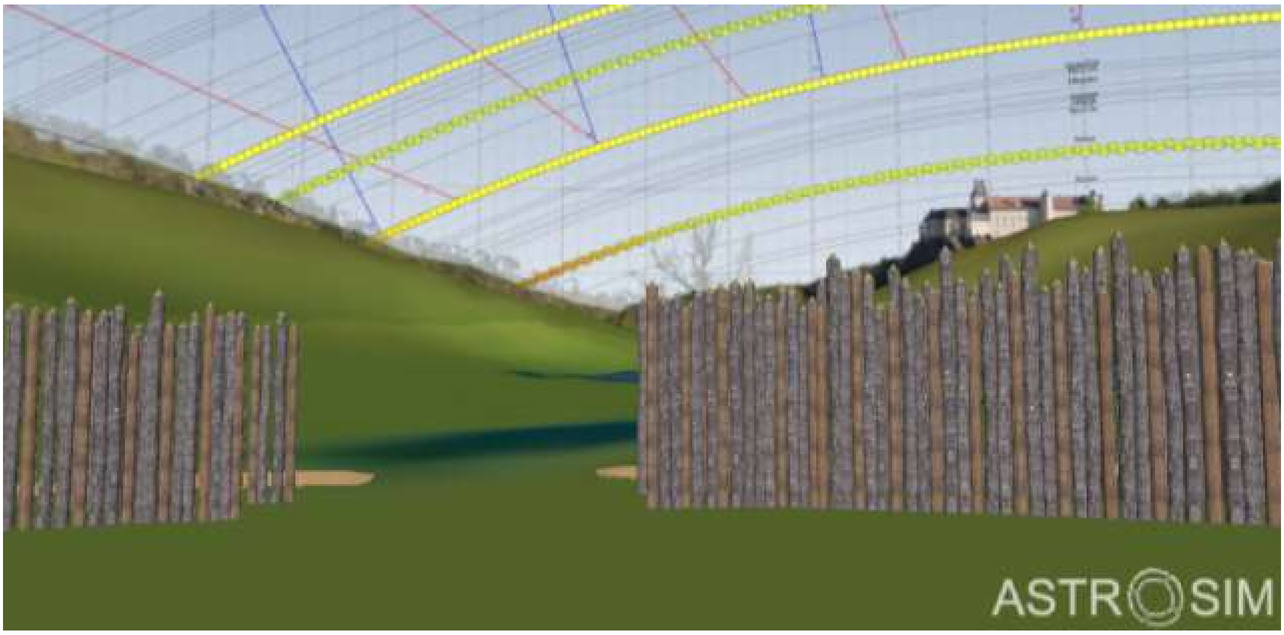

Figure 5. A view from the centre of the virtual reconstruction of KGA Rosenburg through the south-east entrance shows winter solstice sunrise over the mountains (third chain of circles from left) at an altitude of almost 7 degrees, in line with the left edge, but not the centre of the entrance. Omission of such horizon altitudes influences the result of previous studies. However, the rather wide entrance also aligns centrally with lunar major standstill (lowest chain of circles). This shows the ambiguity of even such an approach, in cases where the entrances are not narrow enough to allow sharp determination of azimuths.

astronomical data like diurnal tracks of brighter stars or solstice and lunistice curves for the respective epoch. These combined diagrams can now be directly used to read declinations or celestial objects *on the landscape horizon* for the azimuths in question (Figures 3, 4). The first visit to a site (Altruppersdorf) suggested also looking for conspicuous hills in the astronomically significant directions. At this site, *Staatzer Berg*, a pyramidal hill, coincides almost with the direction of winter cross-quarter sunset (Figure 3). If such hills or notches on the horizon would have appeared more frequently in our surveys, they could have indicated a motivation for selecting such sites to build a KGA. However, no other place shows such a feature.

Especially for the KGAs in the Kamp valley, e.g. near Rosenburg or Kamegg, the horizon altitude caused by the surrounding mountains certainly cannot be neglected and clearly influence the astronomical result (Figures 4, 5).

In addition, the panoramas provide an astronomically correct visual background for virtual reconstructions of the archaeological structures.

Our three-dimensional virtual reconstructions are based on the magnetograms projected onto a digital elevation model of 25m resolution, with ditches carved out and palisades re-erected where their traces are detectable in the magnetograms. The spatial resolution of the magnetograms is 0.125m × 0.5m, thus ± 0.25m can be assumed as maximum lateral displacement error, verified by various excavations carried out on basis of the archaeological interpretation of the magnetic images. The width of the entrance in the palisades, and therefore accuracy by which a solar date could have been observed, is also frequently uncertain due to the bad state of preservation. We therefore cannot hope to verify high-accuracy alignments involving long lines between edges of assumed former wooden structures, but given the large sizes of the ditches, this technique should allow us to study whether astronomically relevant azimuths lie within the entrances or gaps in the palisades as seen from the KGA centres or from one entrance through another.

Our models allow virtual walks through the architecture *in their landscape*, and allow a much better evaluation of the potential significance of astronomical or terrestrial targets for the entrances in question. It is noteworthy to mention that artificial horizon lines derived for single spots from available digital elevation models sometimes are not accurate enough, especially in cases where the horizon is close, so measurements taken on-site remain an essential part of work for reliable results.

Another potentially interesting aspect for simulation is shadow effects caused by entrances through the palisades. Simulating and animating the first or last rays of the sun being cast into the inner area at astronomically significant dates, e.g. the solstices, may help to discover such intentions of the builders.

A custom-made panorama export option for the modelling software allows us to create static foreground panoramas for selected observer locations to be used with appropriate astronomical simulation software (Figure 8). A further step will be the creation of a direct walk-through mode for the astronomical simulation program, so that celestial simulation can easily be combined with views from any point around the building structures.

First Results

For KGAs with two circular and radial connecting ditches which form “entrance passages”, it has been observed earlier that their axes do not meet in the geometrical centre of the KGA (Pásztor 2008; Zotti 2008). In those cases, it seems more likely that the axes of the entrance passages, or the radial ditches, should be followed, and

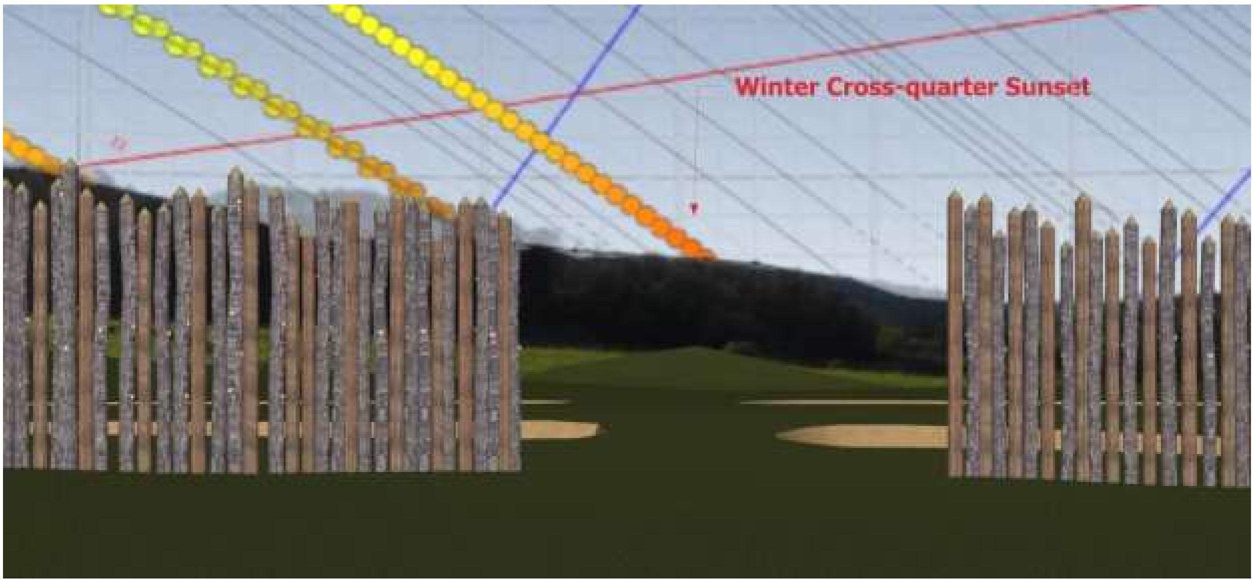

Figure 6. The southwest entrance of KGA Puch seen from the centre of the KGA closely coincides with the setting point of the sun at the winter cross-quarter days on the elevated horizon. The opposing entrance (not shown) points towards sunrise on the summer cross-quarter days on a low far horizon. There, the palisade traces are better preserved and indicate a narrower entrance.

not views from a central location. For single-ditch KGAs with completely eroded traces of palisades, only central places can be assumed, and any results will clearly be less reliable, given that the inner area of KGAs shows no preserved archaeological structures which could have acted as back sights. For such badly preserved sites, we try to define the geometric centre of an idealised circle from the magnetogram and then investigate whether astronomically relevant directions lie within the opening angles of the entrances as seen from there, or from locations within 1-2 steps from this centre if it is not well-defined. (For a circle of 50m diameter, 1m of lateral displacement causes an azimuth error of 2.3°, but typically just in those KGAs entrance orientation cannot be narrowed down to better than several degrees width.)

The orientation of the entrances at KGA Puch towards the rising summer cross-quarter and setting winter cross-quarter days can be confirmed also with the measured horizon. However, at many locations the exact endpoints of the palisades is no longer visible, so that the entrances appear too wide to be able to pinpoint a single day, casting doubts on the previous claims about marking a single day in the solar year, but rather supporting the idea of symbolic orientation.

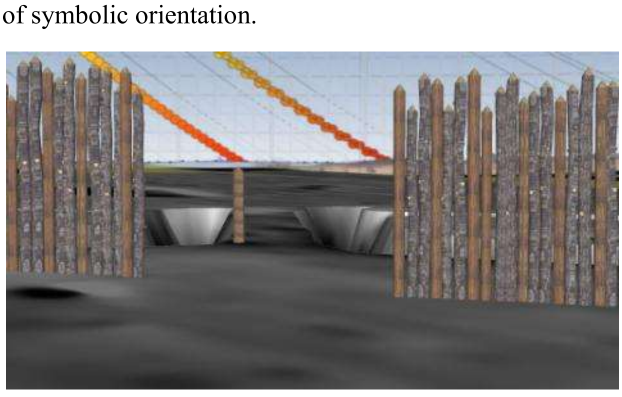

Figure 7. KGA Pranhartsberg 2. Two magnetic anomalies in the north-west entrance, shown here with potential posts in place, are perfectly in-line with summer solstice sunset.

The creation of virtual reconstructions on top of the magnetograms also leads to potential explanations of some magnetic anomalies. For example, in the north-western entrance passage of KGA Pranhartsberg 2 (Figure 2), two magnetic anomalies might indicate post-holes which, if indicating posts contemporary with the KGA, would have accurately pointed towards summer solstice sunset (Figure 7). Of course, this result can only be an interpretative suggestion and should be verified by excavation.

In the previous study, it was assumed that ultimately all entrances might be associated with celestial objects. All entrances outside the solar and lunar arcs had therefore to be associated with stars. The result had to remain somewhat inconclusive for lack of horizon data, especially in the northern and southern horizons where the diurnal tracks of the stars intersect the horizon in a flat angle. The site visits now show that local topography, esp. terrain slope, also must have been an important factor for the entrance orientation. The case of the heavily eroded KGA Gauderndorf at least seems now clear. This KGA has two entrances towards south-southeast and north-northwest, both well outside even the lunar range. However, the connecting line of the entrances closely follows the slope of the rather steep terrain, which invites the simple designation of "upper" and "lower" entrances, completely free of celestial associations. It seems therefore that not all KGAs include celestial elements, and certainly astronomical observation was not the most important motivation for their construction.

It is especially noteworthy that the palisades of the KGAs which were erected in sloping terrain could most likely not have formed a closed horizon line, so that parts of the surrounding terrain, like the opposing hill behind the valley, remained visible above the assumed height of the palisade (see also Figure 3). This also means that some entrances which lead down the slope fail to intersect the sky, and again might not be associated with celestial objects at all. Figure 8 shows the case for KGA

Figure 8. A view of the Greater Dog, Orion and Taurus (with Pleiades at right), as they would have appeared side-by-side on the horizon in 4700 BC. The south-western entrance in KGA Steinabrunn, although indeed almost sharing the setting azimuth of the star Rigel (lower centre) as suggested earlier, is too low to visually intersect the horizon. In this reconstruction, the palisade is 2.4m high. To intersect the horizon as seen from this central location, it would have to be more than 4m high. (Simulation with Stellarium, an open-source desktop planetarium.)

Steinabrunn, where we previously had suggested a potential association of the south-western entrance with a setting of the star Rigel. However, this entrance lies considerably lower than an observer close to the centre of the KGA, so that the palisade or single posts in the entrance area would have to be more than 4m high to hide the horizon and visually enclose a star (if this would have been the intention). At least this stellar association, although correct in azimuth, therefore now appears less likely. The opposing, upwards-leading entrance can on the other hand be confirmed to coincide with the rising azimuth of Deneb, as previously stated.

Conclusions

We cannot give a final result at this stage of the project. Many more models need to be built and evaluated, and some more simulation software is still under development. This work should be completed later during 2011.

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