

STONE-AGE BURIALS AS A HINT TO PREHISTORIC ASTRONOMY

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ABSTRACT

The authors describe statistical studies of neolithic burial sites in central Europe and conclude that the alignments of graves and bodies show that stone-age people had abstract concepts of the cardinal directions of the compass, rather than simple notions of the direction of sunrise. They describe how such peoples may have determined the cardinal directions and compare (unfavourably) the astronomical knowledge of those who buried the stone-age dead with that of many modern people. They also draw some demographic conclusions from their study.

In the 1950s the knowledge of Bronze-Age astronomy made great progress through the study of the great megalithic lunar and solar observatories in Britain by the Thoms, Hawkins, and others. Although critical statistical examinations and archaeological excavations on the sites have since considerably reduced the unambiguous evidence, it appears certain that megalithic astronomers between 2300 and 1200 B.C. were able to determine at Stonehenge sight lines of moon and sun risings and settings at peculiar dates like the summer solstice to within 2 arc minutes (cf. Atkinson 1982).

At the Astronomisches Institut der Ruhr-Universität Bochum we tried in the last years to extend the horizon into the earlier past. For this purpose we decided to study the orientation of neolithic burials. Before 3000 B.C., burials seem to be the only evidence of astronomical knowledge which survived. Further, thousands of burials have been unearthed so that statistical treatment of the data is possible. Peculiar results on individual graves might seduce us into unfounded speculation, but extensive data yield themselves to sound statistical analysis. The archaeological basis was provided by close cooperation with Profs. Mildenerger and Čierny from the Lehrstuhl für Ur- und Frühgeschichte. With the invaluable help of these experts hundreds of publications had to be evaluated, many of them only of local circulation. As far as possible published records and maps were traced back to the originals, often the only hope to distinguish between true and magnetic north, or other open questions. All relevant data were stored in a data-bank for further processing. A detailed analysis with references is given in Schlosser *et al.* (1979, 1981).

1. Orientation of Neolithic Burials. As a first step the discoverers' descriptions of late neolithic sites in Bohemia and Moravia were collected and sifted. The neolithic period in central Europe is dated between about 5000 B.C. (or somewhat



FIG. 1—Looking closely south, this female skeleton demonstrates the high level of astronomy and geometry in the neolithic period more than 5000 years ago. Photo: Courtesy Bayerisches Landesamt für Denkmalpflege.

earlier) and 1800 B.C. It was already known that burials were oriented to the cardinal directions of the sky. As a matter of fact, the title of a paper by Büsching as early as 1824 reads “Die Richtungen der Gerippe nach den Himmelsgegenden” (The Orientation of Skeletons to the Cardinal Points).

Our work started with the corded-ware and bell-beaker civilisations of the late neolithic period and was based on 1445 burials of around 2000 B.C. (or 2300 B.C. according to carbon-14 dating). All burials were individual graves in contracted inhumation, often with additions like ceramics, axes, ornaments. Most of the graves were found in fertile areas suggesting developed agriculture. It is assumed that the corded-ware (or battle-axe) people came from the east and spread over southern Scandinavia and Germany while the bell-beaker people came from the Iberian peninsula spreading over the whole western Europe up to Hungary and southern Poland. Fifteen features of each finding were used in the final analysis. Only excavations by expert archaeologists were taken into account.

After this program had been finished in 1979, 1004 additional burials of the early neolithic period (linear pottery) in Central Europe were studied, a period which is dated around 4000 B.C.

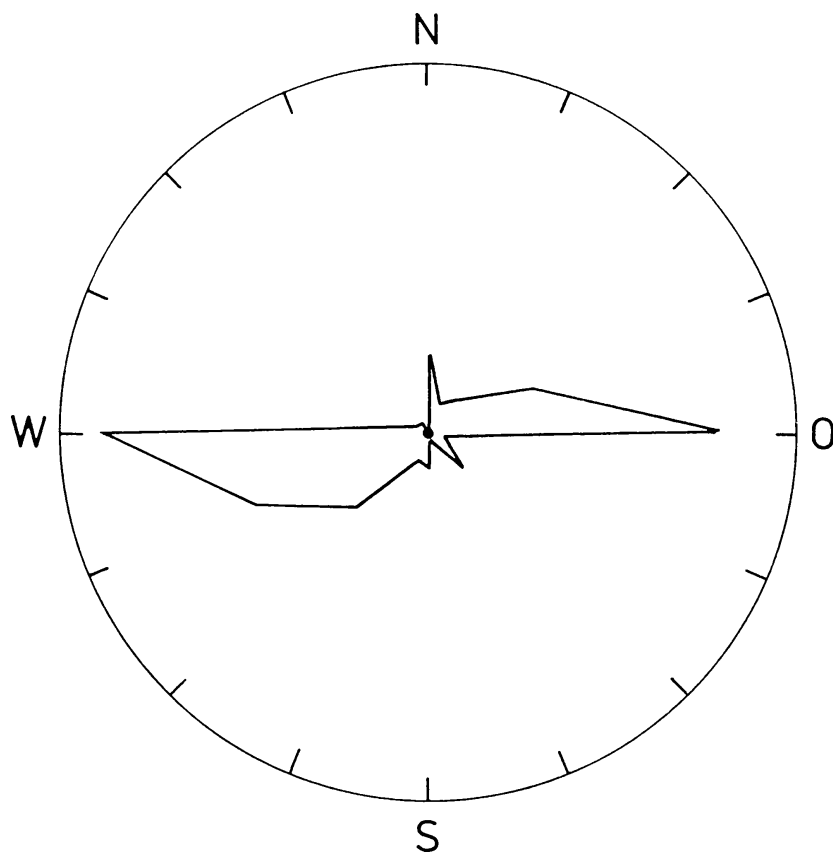


FIG. 2—The directions of the body axes of Bohemian battle-axe people (2000 B.C.). The number of findings is given as a function of the azimuth. The east-west preference is well recognizable.

The results of both investigations were astonishing: the *late neolithic* battle-axe people buried their dead almost exclusively in the direction east-west, men laid down on the right side, the eyes looking south, women laid on the left, the eyes also looking south (figures 1, 2, 5). The bell-beaker people of about the same period carefully buried their dead north-south, the eyes looking east, the scatter of the angle with the meridian being less than 6° (figures 3, 6). Much of this scatter is still due to the restricted accuracy of the position descriptions of the archaeologists, but also to postmortal motions etc.* Directions from grave pits are usually

*An anonymous referee surmised that an archaeologist would “describe in field notes the direction of orientation of a bunch of bones” in the following way: “If the skeleton lay more or less E-W write down as E-W. Statistical analysis of a host of these approximations would reveal “surprisingly” cardinal directions.”

Of course such is not the practice of more modern archaeology. The majority of field reports indicates directions based on the 16 directions of the compass, i.e. 22.5° between adjacent directions. The orientation (north) is usually based on maps with scale 1:25000 or better. If the relevant publication contained a sufficiently large-scale map with north arrow, we redetermined the body and grave orientations in a direction scale of 32 parts, i.e. with 11.25° between adjacent directions.

First the reliability and accuracy of all reports was evaluated in a scale 1–5; older excavations, or

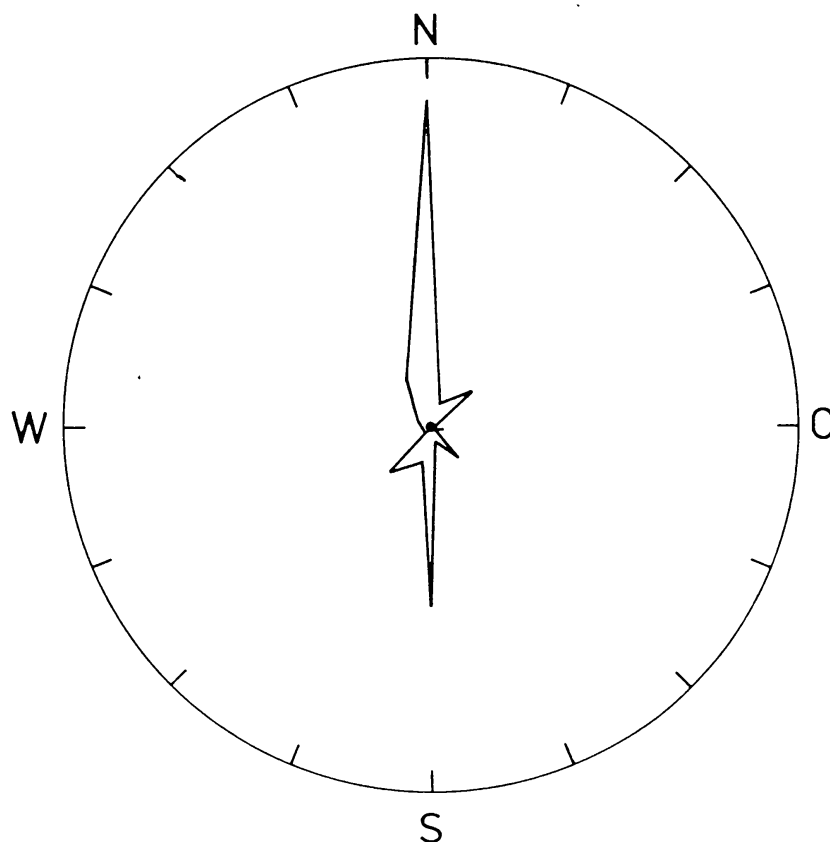


FIG. 3—Same as figure 2 for the Bohemian bell-beaker people (2000 B.C.).

better determined than from skeletons. In the case of three recently excavated large burial fields it was possible to determine the directional accuracy of the rectangular grave pits to better than 2° , probably even better than 1° . The accuracy of the average cardinal directions turned out to be at least as good as that.[†] The probability that these preferential directions are the result of chance is extremely low. Making the hypothesis that the bell-beaker people prepared their burials so that their dead were looking east, the Kolmogorov test assured that the opposite hypothesis has a probability of 10^{-72} .

The *early neolithic* burials were generally oriented east-west, the head lying to the east and the eyes mostly looking south. The mean orientation of the grave pits of the largest grave field (Aiterhofen) deviates as little as 0.1 ± 1.4 from the direction east.

excavations not by qualified archaeologists, or with unsatisfactory reports, were excluded. The exact cartography of the grave field Vikletice (M. Buchwaldek, D. Koucky, Prague 1970) allowed determination of the orientation of the 180 grave pits within 2° intervals of azimuth. In the case of the grave field Aiterhofen, where the excavations were still under way, the original reports are accompanied by maps of scale 1:10 allowing even better determinations.

[†]Vikletice ($A = 90.0 \pm 0.7$), Senghofen ($A = 87.4 \pm 2.5$), Aiterhofen ($A = 90.1 \pm 1.4$). See also explanations to Figure 7.

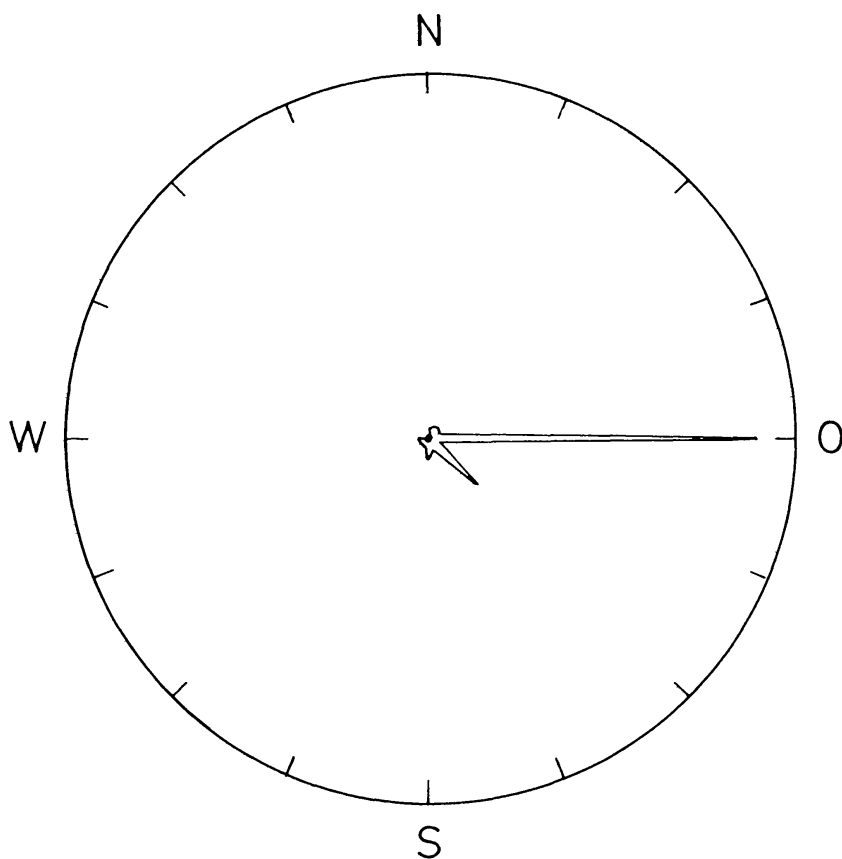


FIG. 4—Same as figure 2 for the directions of vision of the Bohemian bell-beaker burials.

Summarizing, it seems established that early and late neolithic man of central Europe had a notion of the abstract ideas “East”, “West”, “North” and “South”, – rather than the simple notion of the directions of sunrise and sunset – and that he was able to realize this notion with an accuracy of (probably better than) 1° .

2. *Inferences on Neolithic Astronomy.* How could the stone-age people achieve the observed accuracy of determining the cardinal directions? A modern man confronted with the task of determining the south-north direction would take a compass or the position of the sun at noon. Thus he would be quite inferior to the stone-age priest if he failed to allow for the magnetic declination of his compass, for the time equation and his longitude. At local noon the shadow of the sun is shortest; however, the sun is a disk of 0.5° diameter so that the shadow is not sharp. Even with a perfect shadow rod and a perfectly flat and homogeneous projection area, in our latitudes an error of $\pm 5^\circ$ for the meridian direction would result. Theory and practice show that under optimal conditions the end-point of the shadow of a rod can be defined at $\pm 3'$; this limits the direct determinations of the direction south in the relevant latitudes to about $\pm 5^\circ$. The accuracy even of early

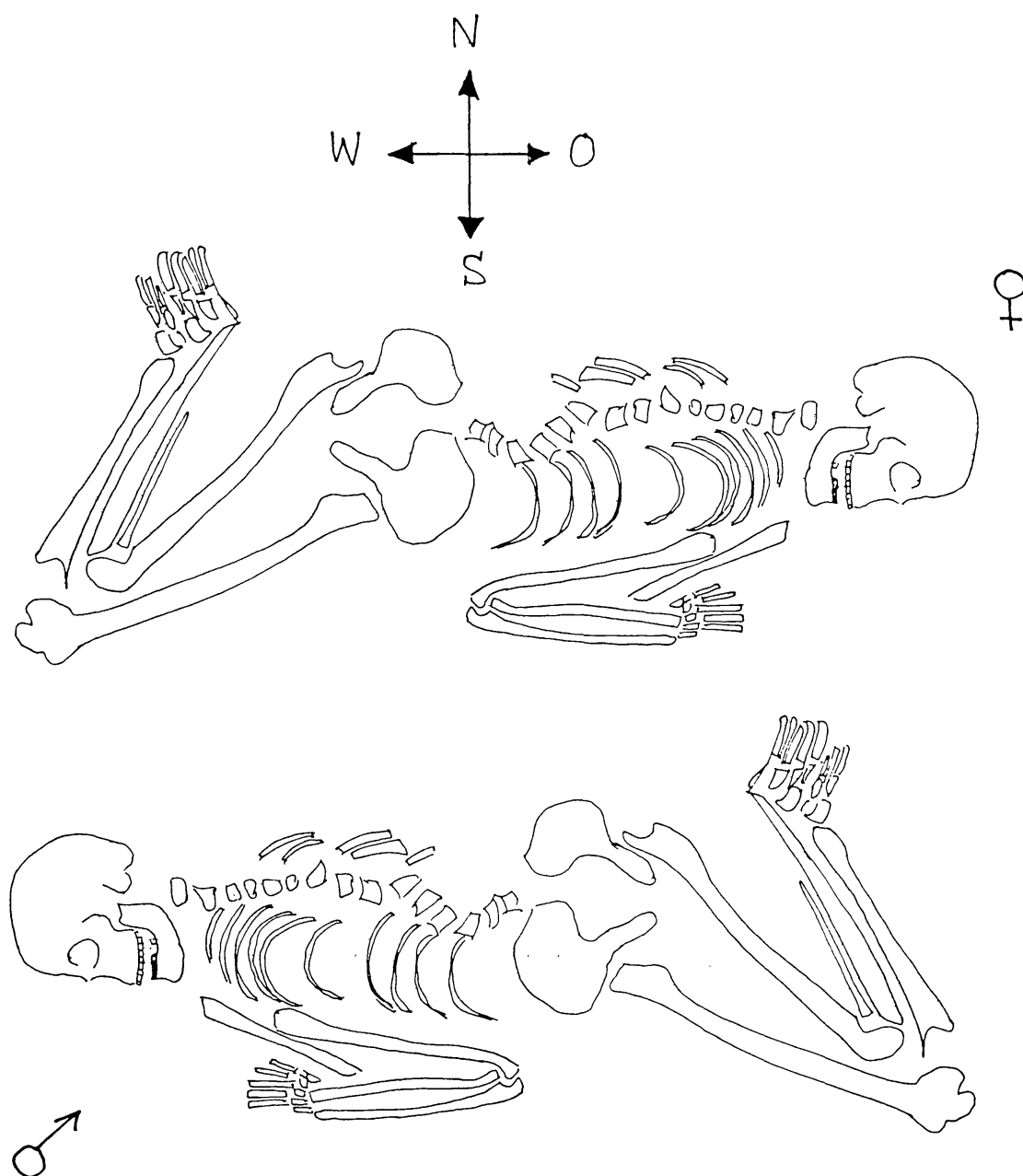


FIG. 5—Battle-axe people buried their dead in east-west direction looking south, women lying on the left side, men on the right side. Body axis is defined by the line occipital hole – centre of pelvis.

neolithic burial sites is an order of magnitude better, thus demonstrating the use of more developed techniques.

Therefore, the stone-age people must have used an indirect method. Such a method is indeed known from antiquity as the “Indian Circle,” and is still in use in Kurdistan and Afghanistan for calendar purposes: around the vertical shadow-rod a circle is drawn which is touched by the shadow twice a day. Bisecting this angle, the exact meridian is obtained.

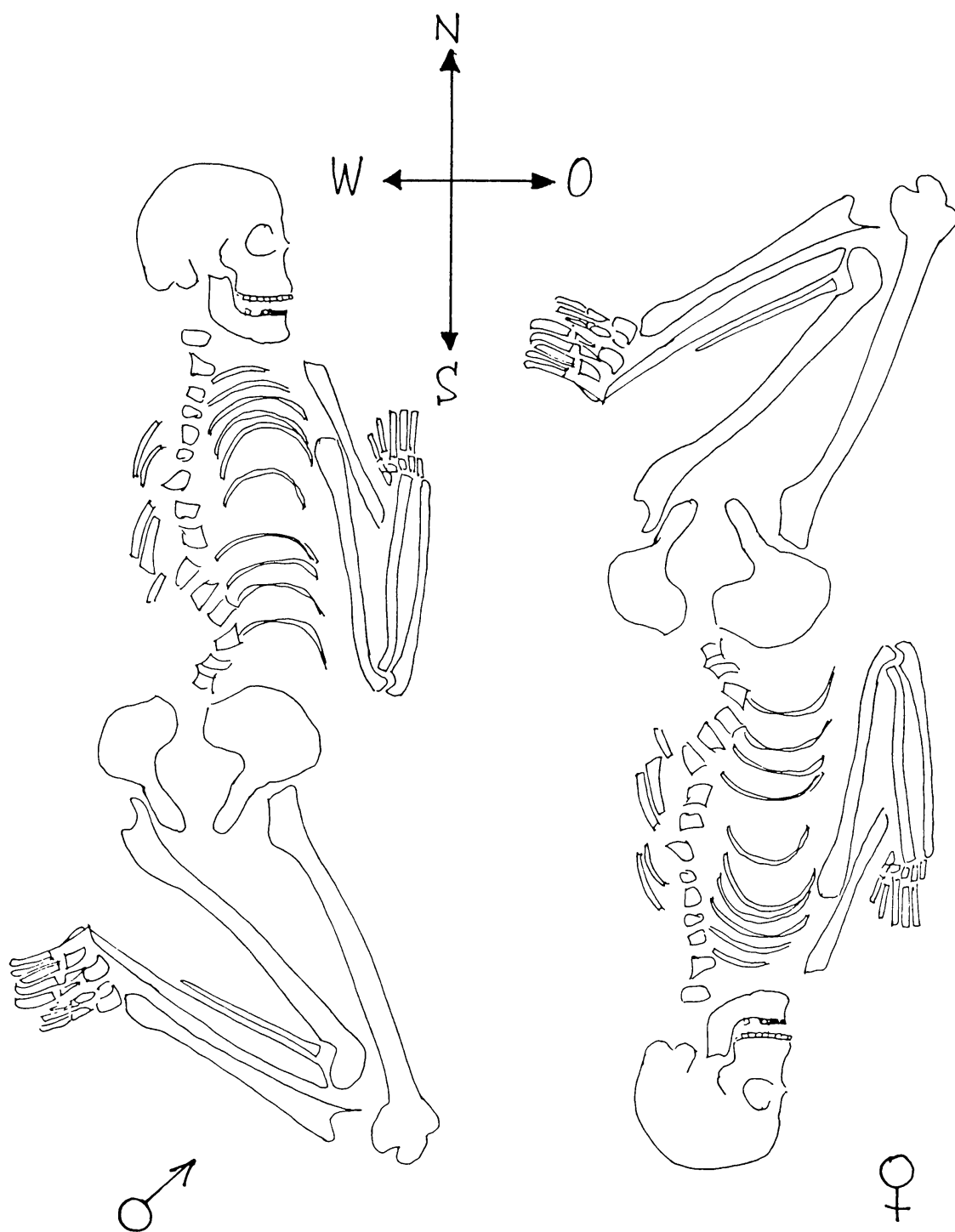


FIG. 6—Bell-beaker people buried their dead in north-south direction, looking east, women preferentially lying on the right, men on the left side.

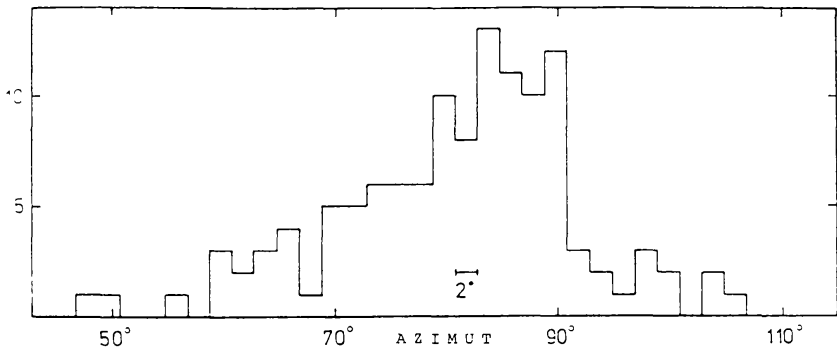


FIG. 7a—Distribution of the orientations of grave pits in the burial site Vikletice (Bohemia, battle-axe people, about 2000 B.C.). A considerable part of the large deviations from $A = 90^\circ$ seems to be due to perturbations of the graves. The skew distribution around 90° may indicate that it was permissible to bury somewhat to the north, but that it was an offence against ritual to deviate south. The same skewness is observed in the distribution of the body axes of the whole of the battle-axe people burials. The mean direction of Vikletice burials is $A = 90^\circ 0 \pm 0^\circ 7$ m.e. The sharp decline in frequency from $A = 90^\circ$ to 92° shows that the orientation of the grave field as a whole was better than $\pm 1^\circ$.

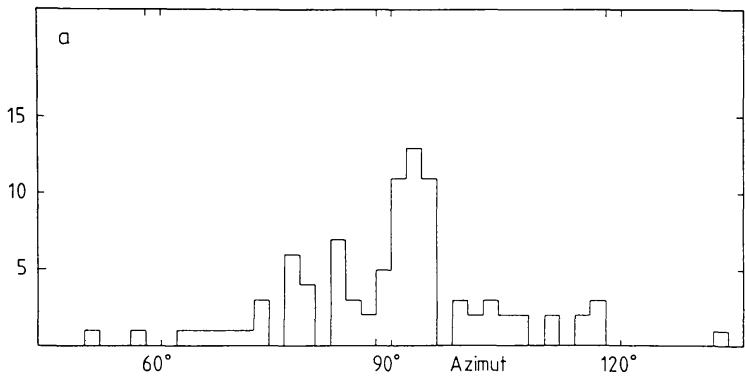


FIG. 7b—With 167 graves, Aiterhofen (Bavaria) is the most extensive early neolithic burial site in our survey. The stone-age people (linear pottery, 4300 B.C.) did not use the true azimuths of sunrise (see figure 7c), but the abstract direction east ($A = 90^\circ$). The same remarks as for figure 7a apply here. The mean direction is $A = 90^\circ 1 \pm 1^\circ 4$ with a scatter of $\sigma = \pm 13^\circ 4$. The orientations of skeletons is less well determinable, we find $A = 94^\circ 5 \pm 1^\circ 8$ with $\sigma = \pm 15^\circ 8$.

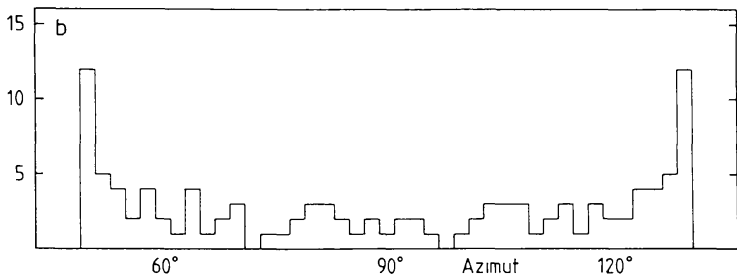


FIG. 7c—Distribution of the orientations for a hypothetical population burying the dead according to the actual sunrise azimuth.

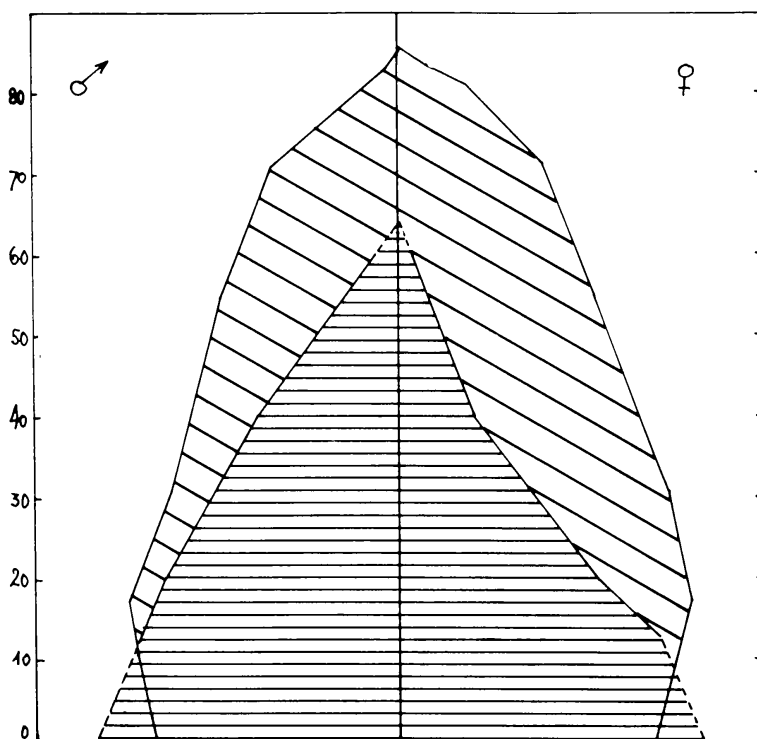


FIG. 8—The age distribution of the neolithic population of central Europe (horizontal shading), averaged over all skeletons with anthropological description (5000–1800 B.C.). No significant deviations between various periods and civilisations could be detected. For comparison: (oblique shading) the population profile of the region of the Federal Republic of Germany (averaged over 1939–79 in order to smooth out catastrophic events like the wars and the great depression).

In the following table we finally compare the quality of early astronomical observers mostly by the accuracy of their shadow measurements. It is remarkable that the precision of astronomical measurements declined with the lapse of time, at least after the classical period (Hipparchos). The measurements of Copernicus did not exceed those of the late antiquity in accuracy. It was Tycho's instrumental art, introducing new tools, which led first to a higher accuracy than $1'$ for the positions of both, fixed stars and planets, leading in turn to Kepler's laws as the foundation of modern science.

3. Neolithic Demography. An interesting side-line of our study concerns the population of stone-age people. About a quarter of the skeleton remains have been classified by anthropological features into 5 classes (infantile, juvenile, adult, mature, senile) corresponding to the age classes 0–12, 13–19, 20–40, 41–60 and over 60 years. We have reconstructed from the age distribution of the dead the age pyramid of the living, assuming a stationary population. The same population pyramid resulted within the errors for the early and for the late neolithic as well as for the various cultural stages. The greatest problem was to account for the badly

TABLE I
ACCURACY OF DIRECTIONAL MEASUREMENTS AT DIFFERENT EPOCHS

Period		Epoch	Accuracy	Instrument
Neolithicum	early	4500 B.C.	} <0°5–1° (2')* (1')*	Indian Circle
	late	2500 B.C.		
Ancient Egypt	pyramid of Cheops	2700 B.C.	2'5–5'5	harpenodaptes ("fathom stretchers" – a professional caste of ancient Egypt)
Bronze Age	Stonehenge II	2150 B.C.	2'	
Classical Antiquity	Pytheas of Marseille	300 B.C.	6'	gnomon (shadow rod)
	Eratosthenes of Alexandria	250 B.C.	6'	armillary sphere
	Hipparchos of Nikaia	150 B.C.	6'	shadow rings
	Poseidonios	90 B.C. to 370 A.D.	ca. 25'	gnomon
Late	Vitruvius			
	Plinius			
	Geminus			
	Ptolemaios			
	Kleomedes			
	Ptolemaios	150 A.D.	8'	quadrant

*The figures referring to the stone age have been put in parentheses to indicate the *hypothetical* accuracy which would have been necessary if stone age astronomers had *not* known the Indian Circle.

known baby mortality; infants' bones are not as well preserved as those of grown-ups, and perhaps they were not buried with the same diligence. We found a mean life expectancy of 24 years, for women 20, for men 27 years. For comparison: the life expectancy in Germany is now about 75 years (disregarding infant mortality). The lower life time of women was apparently a result of child-birth; in the age class 13–19 years deaths of females are much more frequent than for males. The average woman had five children surviving the suckling age. It is most important that the age pyramid did not change significantly between 5000 B.C. and about 1800 A.D. This means that basic life conditions of the average man have remained essentially constant since the neolithic revolution, which introduced agriculture and cattle-farming instead of hunting and gathering. In our times a revolution of life conditions is again taking place, mirrored in the increase of life-times.

4. *General Education in Astronomy: Nowadays and 5,000 Years ago.* It is ironic that modern people in many instances do not have the basic astronomical

knowledge of stone-age people. Before public lectures we have sometimes presented the following quiz:

1. In which direction does the sun reach its greatest height?
North East South West
2. Does the sun attain its greatest height each day in the same direction?
Yes No
3. Where does the moon reach its greatest height?
North East South West
4. Using a cord (fixed on one point) to describe a circle and a cord (fixed by two points) to define a straight line, how would you construct
a) a right angle? b) a bisecting angle?

This quiz requires exactly the mathematical and astronomical knowledge of 7000 years ago as inferred from the stone-age burials. It is amusing to compare the score of a school class or a cocktail party in the “stone-age quiz” with the knowledge of primitive man.

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