sediments in this core do not record continuous deposition. Core RC 11-256 contains an apparent hiatus at the upper boundary of the event. Therefore, a rate of deposition based on the sediments of the X zone in cores RC 11-248 and RC 11-256 is meaningless, because a complete record of the event is not present in either case.

The lower boundary of the X zone in RC 7-4 is in flow-in, and the sedimentation rate for this core is not reliable. The core RC 7-2 was taken from the Blake Outer Ridge in a zone of intermittent nondeposition or mild erosion, or both (*7*) which tends to preclude a dependable sedimentation rate.

In contrast to the cores mentioned above, V 20-174, A 179-4, and RC 10-49 show no lithic evidence of breaks in sedimentation and appear to represent continuous deposition in a relatively stable environment. Since the dates assigned to the boundaries of the X zone are based on radiometric measurements of Caribbean sediments, we consider cores RC 10-49 and A 179-4 the most reliable for estimating the age and duration of the magnetic event. On the basis of the rate of sedimentation within the X zone of these two cores, the boundaries of the Blake event are placed at 108,000 and 114,000 years ago ± 10 percent.

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30 August 1968; revised 15 October 1968

Megalithic Plan Underlying Canterbury Cathedral

Abstract. *Woodhenge and the Trinity chapel, Canterbury, are strikingly similar in outline. One is megalithic, the other Norman Christian over Saxon Christian. An analysis of the geometry shows that both are based on Pythagorean triangles: Woodhenge with sides, 6, 17.5, and 18.5, and Canterbury with sides 12, 72, and 73 in megalithic yards. The structurally more recent eastern end of Canterbury Cathedral may have been built over and around an older megalithic site. The longitudinal axes of the composite cathedral differ by 2°, and these, if aligned on Betelgeuse, would indicate buried megalithic structures dating from 2300, 1900, and 1500 B.C.*

The visitor to Canterbury Cathedral who is fortunate enough to fall in with the retired clergyman, serving as volunteer guide, whose hobby and pride are the history, clerical and architectural, of the great edifice, will have his attention drawn to the misalignment, approximately 2°, between nave and choir. He will see a further deviation of 2° to the south between the choir and the Trinity chapel (Fig. 1). The chapel is apse-shaped with "horseshoe" rather than parallel sides. At the far end, a small circular chapel, the principal apse of the cathedral, named the Corona, or Becket's Crown, lies on the axis of the Trinity chapel. St. Andrew's chapel on the north and St. Anselm's on the south are symmetrically spaced with respect to the Trinity chapel but not with respect to the choir.

Woodhenge is a megalithic monument 3 km from Stonehenge. It is assumed to be of the same age as the early Stonehenge phase of construction (1800 B.C.). It consists of 160 postholes arranged in six concentric symmetrical figures, and is surrounded by ditch and outer bank (*1*). Thom (*2*) made a precise survey of the site (Fig. 2c) and finds that (i) the arcs at the large (major) end have a common center α; (ii) the arcs at the small (minor) end have a common center β; (iii) the distance between the centers $\alpha\beta$ is 6 megalithic yards of 2.72 feet or 0.829 m; (iv) each minor radius is 1 megalithic yard smaller than the major radius; (v) the arcs connecting major and minor ends have a common center at γ.

Figure 2c shows the triangle $\alpha\beta\gamma$ on one side of the axis only. Circular arcs from α and β differing in radius by 1 megalithic yard are connected by an arc from γ to form the oval. Arcs from a corresponding point on the other side of the axis (not shown) would complete the oval. The point γ must be 1 megalithic yard farther from β than from α in order to connect the two ends. If the triangle is a right triangle, the hypotenuse will exceed one side by one unit.

The marvel of Woodhenge is that the triangle $\alpha\beta\gamma$ has the proportions 12, 35, and 37. This makes a perfect Pythagorean triangle, that is, a right triangle having integral sides so that the sum of the square of the two sides equals the square of the hypotenuse, $12^2 + 35^2 = 37^2$. If laid out in megalithic yards, the major and minor radii would differ by 2 megalithic yards. If, how-

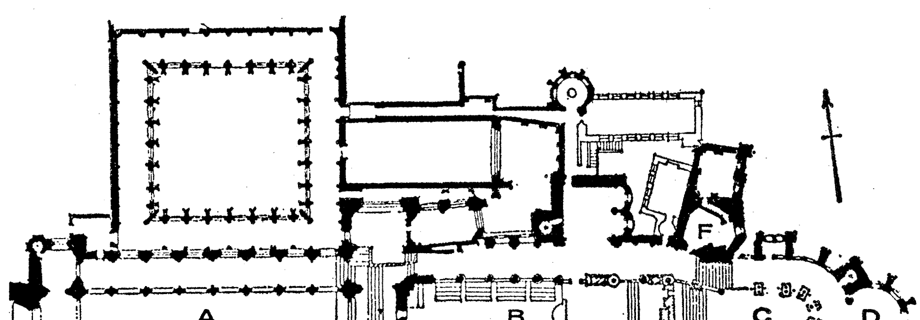

Fig. 1. Canterbury Cathedral. (*A*) Nave; (*B*) choir; (*C*) Trinity chapel; (*D*) Corona; (*E*) St. Anselm's chapel; (*F*) St. Andrew's chapel. [Original drawing from H. Batsford and C. Fry, *Cathedrals of England* (Batsford, London, 1960), p. 43]

ever, the half megalithic yard was used, making a triangle 6, 17.5, and 18.5 megalithic yards, the relation of the sides would continue to be 12, 35, and 37, but the major radii would exceed the minor by 1 megalithic yard, and the distance between centers $\alpha\beta$ would be 6 megalithic yards, as found by Thom. There is no doubt that Pythagoras' theorem was being applied, although not proven or understood, 1000 years before Pythagoras.

Now let us analyze the crypt below the Trinity chapel, known as the crypt of William the Englishman (Fig. 2, a and b). The distance between centers α and β is 2 rods but, within the precision of the available plans, this is 12 megalithic yards. The Woodhenge-type ovals of Fig. 2b are derived from triangles with sides of 12, 72, and 73 megalithic yards. Although these are not mathematically true Pythagorean triangles ($12^2 + 72^2 = 5328$, while $73^2 = 5329$), the deviation is 1 in 5000 and would escape detection. The large ends of the Woodhenge ovals are again 1 megalithic yard larger in radius than the small ends, and the major radii are 6 and 12 megalithic yards. The circular cavity below the Corona (Fig. 1, *D*) is 5 megalithic yards in radius and is tangent to the larger oval. The smaller oval is tangent to the line between centers of St. Gabriel's chapel (Fig. 2a, *E*), beneath St. Anselm's, and the symmetrical chapel of the Holy Innocents (Fig. 2a, *F*) beneath St. Andrew's. The centers of the two chapels and the center of curvature of the large ends α form three corners of a square. The double columns of the crypt, and those of Trinity chapel above, are oriented perpendicularly to the smaller Woodhenge oval and are therefore not perpendicular to the center line. The two columns *p,p* of Fig. 2, a and b, fall on the larger Woodhenge oval. Although the circle of the Corona is tangent to the circular wall of the Trinity chapel, in the crypt the horseshoe is slightly deformed from a true circle for structural reasons.

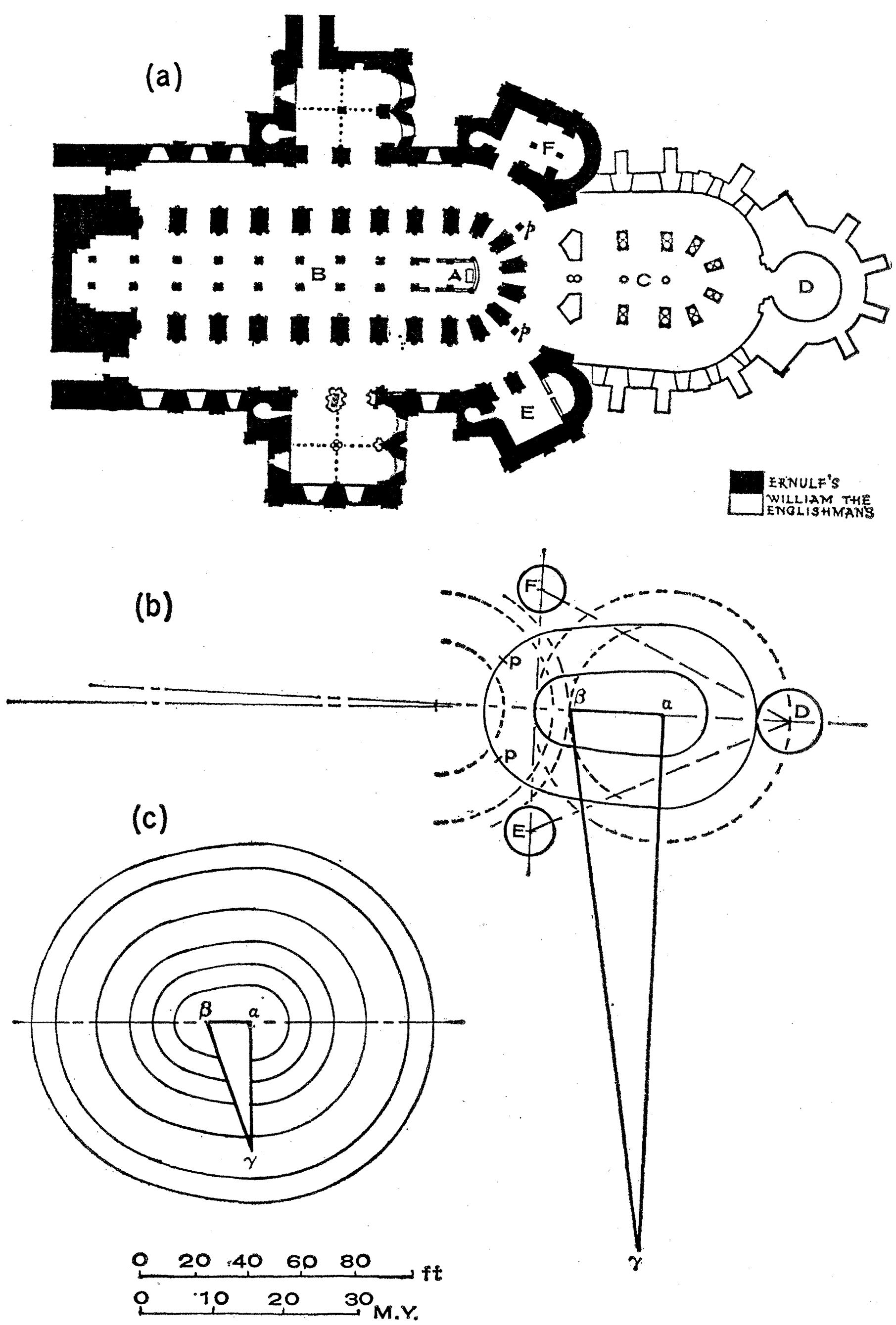

Fig. 2. Comparison of eastern end of Canterbury Cathedral with Woodhenge. (a) The crypt. (*A*) Altar of Our Lady Undercroft; (*B*) Ernulf's crypt; (*C*) William the Englishman's crypt; (*D*) small chapel under Corona; (*E*) chapel of St. Gabriel; (*F*) chapel of the Holy Innocents; *p,p* columns added by William the Englishman. (b) Geometry of the crypt of William the Englishman. (c) Geometry of Woodhenge.

The centers of the three small apsidal chapels form an isosceles triangle of base 34 megalithic yards and altitude 34 megalithic yards. This triangle can be divided into two right triangles with a common side, each approximately Pythagorean: $17^2 + 34^2 = 1445$; $38^2 = 1444$. The elegance of the geometrical design shows a carefully conceived and executed plan.

Little is known of the Anglo-Saxon church which occupied the site before the Norman Conquest. Bede (*3*) was informed that it had been built by Roman Christians. However, it burned in A.D. 1067 and was entirely removed by Lanfranc before the construction of the Norman cathedral. The original Norman nave and transepts were finished in A.D. 1077 (*4*). The undercroft, choir, St. Anselm's and St. Andrew's chapels, initiated by Prior Ernulf about A.D. 1100, were dedicated by Prior Conrad in 1126. After the assassination of Archbishop Thomas Becket in 1170, the body of the martyr was enshrined "behind the altar of Our Lady Undercroft" (*5*). The choir was gutted by fire in 1174, but was immediately rebuilt. Between 1180–81, the cathedral was extended into the monk's cemetery by William the Englishman to form the crypt, Trinity chapel, and the Corona. At the same time, the two columns *p,p* of Fig. 2a were added to Ernulf's crypt.

The alignment at Woodhenge and at Stonehenge is toward the point on the horizon at which the sun rises at the summer solstice. This rising point has been constant within 0.5° during the past 4000 years. Other solar system alignments such as the equinoxes and the winter solstice are equally fixed. In other megalithic monuments, however, the axis may be aligned upon a point on the horizon too far north to be assigned to sun or moon. Many circles are aligned upon the rising and setting points of the star Capella, a smaller number upon Deneb. The precession of the equinoxes causes the rising and setting points to migrate so that such monuments can be dated. Ten monuments aligned on Capella indicate a date near 1800 B.C. At Canterbury, the axes are oriented slightly south of east for nave, choir, and the Trinity chapel. The declination of the star may be calculated from the direction of the horizon point, the height of the horizon point above the true horizontal, and the latitude of the geographical location. When so determined, the axis of the Trinity chapel points toward the rising point of a star of declination $-6°$; the axis of the choir, $-4°$; and the nave, $-2°$. The change of declination of stars near the equinoxes, where the rate is greatest, is ½° per century. The interval between planning adjacent parts of the cathedral must be 400 years, so that 800 years must have elapsed between nave and the Trinity chapel. The known construction dates (1067 to 1180) do not provide sufficient time to account for the observed deviations of axes.

Stars near the vernal equinox drift north; those near the autumnal equinox drift south. If the sequence of planning were nave, choir, Trinity chapel, the axes would move south and the star would be near the autumnal equinox. No first magnitude star provides plausible dates. If, however, the sequence were Trinity chapel, choir, nave, the rising point would move north and the star would be near the vernal equinox. Among first magnitude stars, Betelgeuse (in Orion) is the obvious choice because its declination was $-6°$ in 2300 B.C.; $-4°$ in 1900 B.C.; and $-2°$ in 1500 B.C.—quite in accord with dates at Arminghall (*6*) (carbon dated 2300 B.C.); Woodhenge, 1800 B.C.; and Stonehenge 1800–1500 B.C. The dates for Canterbury are approximate and are subject to correction based upon a more precise survey of the site.

Anglo-Saxon churches were often built one after another, end-to-end along an axis (*7*). Perhaps this was a pre-Christian tradition. The sequence of the plans under Canterbury must then have been: (i) a Woodhenge type structure of wood or stone with circles at the positions of the three chapels; (ii) 400 years later a structure with apsidal end added west of the existing structure but aligned with the contemporary rising point of Betelgeuse; (iii) after still another 400 years, a second addition added west of existing structures, again aligned with the contemporary rising point of Betelgeuse. Of the second addition, nothing remains, for all vestiges of the Anglo-Saxon church were removed before erecting the Norman nave. Only the alignment of the Anglo-Saxon church was preserved. When the choir was added, it was placed upon the earlier plan (ii). In this addition, the chapels of St. Anselm and St. Andrew were incorporated even though they were not symmetrically located. After Becket's assassination, when a chapel was planned for the display of his sacrophagus, the church was extended eastward into the monks' cemetery. Again, old foundations or an old geometry [perhaps preserved by postholes, (i)] were used.

Corroborative evidence for this proposal is obtained from an analysis of the side chapels, the two columns designated *p,p,* and the arrangement of columns in Ernulf's crypt (Fig. 2a). Literary evidence leaves no doubt that the chapels of St. Anselm and St. Andrew were part of the choir construction of A.D. 1100. Yet they form Pythagorean triangles with the Corona, and so were related to the Corona. Their incorporation into the choir was then a matter of convenience. The columns *p,p* of Fig. 2a serve no structural purpose. They were added as part of the Trinity chapel construction. Their positions on the larger Woodhenge oval are evidence that their locations were part of the henge plan used for the Trinity chapel. The columns must therefore preserve the location of previous standing stones or postholes. Examination of the columns forming the apsidal end of Ernulf's crypt discloses that they are not symmetrically located with respect to the center line. Those to the south have smaller spacing than those to the north, so that the center line grazes one of the columns. The axis of the Trinity chapel, Corona, and the two side chapels, however, passes symmetrically between the two columns.

The fire of A.D. 1170, which destroyed the roof of the choir, weakened the walls but did not damage the crypt. In the reconstruction, the new choir was built upon the old crypt, and the present Trinity chapel and Corona replaced a small rectangular crypt and chapel. Nothing was altered in Ernulf's crypt except for the addition of the two columns *p,p* (Fig. 2a). These columns, the positions of the two side chapels and the asymmetry of the columns are strong evidence that construction of Ernulf's crypt had been adapted in 1100 B.C. to accommodate venerated plans, positions or structures to the east which were part of the monks' cemetery. The later construction of the Trinity chapel made use of these ancient positions and relations.

The available surveys of Ernulf's crypt show no evidence of a horseshoe plan; columns and walls are shown as parallel. However, in the choir above, the walls are curved and not quite parallel, being separated by 32 megalithic yards near the altar, and 30 megalithic yards near the transept. If one attributes the lack of parallel walls again to a Woodhenge oval, the distance between the centers of the circular ends would be about 50 megalithic yards. The new Pythagorean triangle required to generate a Woodhenge oval in which major radii exceed minor radii by 1 megalithic yard would be 50, 1250, and 1251. Such a plan would certainly represent a more advanced culture than that responsible for Woodhenge or the Trinity chapel, and hence a later date. The best measurements which can be made upon available plans indicate a center of curvature 700 megalithic yards distant. Further measurements at Canterbury would be required to confirm this interpretation.

The construction in A.D. 1077 of the nave at Canterbury would therefore appear to conform to the axis of the 7th-century Anglo-Saxon church. Ernulf's crypt when added in A.D. 1100 followed an old plan or foundation, yet its structure was asymmetric and provides evidence of a yet older plan east of the cathedral in the monks' cemetery. When the Trinity chapel and the Corona were constructed in A.D. 1180, this older plan was followed. The result was the horseshoe shaped Trinity chapel with a geometry similar to Woodhenge, which was originally aligned with the rising point of Betelgeuse in 2300 B.C.

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26 September 1968; revised 12 December 1968 ■

Sedimentary Rock Types: Relative Proportions as a Function of Geological Time

Abstract. *Proportions of sedimentary rock types remaining today differ from period to period. These differences may be chiefly the result of differential rates of deposition and erosion of the various components of the rocks. Lower percentages of limestones and evaporites in Precambrian rocks than in post-Precambrian rocks probably represent selective loss of these more easily removable components from the original deposits.*

The proportions of sedimentary rock types in the geologic column vary as a function of age; for example, evaporites amount to several percent of post-Precambrian sedimentary rocks whereas they are far less than 1 percent of Precambrian rocks of sedimentary origin. It is often assumed that the ratios of sedimentary rock types of a particular age represent the relative proportions of sediment types deposited at that time. We propose that age differences in ratios of rock types may be largely due to differential rates of overturn of sedimentary materials in which the various components of the sedimentary rock mass circulate at markedly different rates controlled by their erodibility.

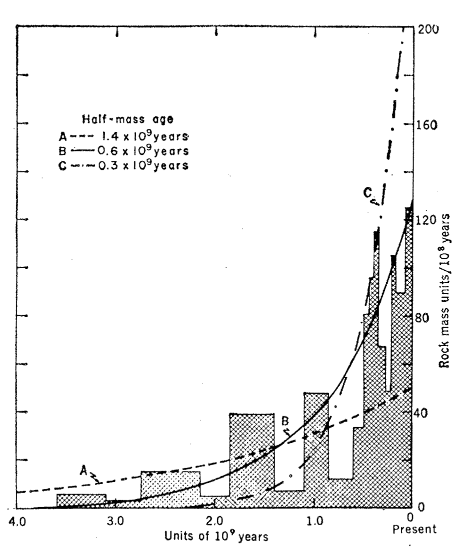

Fig. 1. Distribution of mass of sedimentary rocks as a function of age. Curves based on models that assume the total mass of sediments existing today has remained constant throughout geologic time. Curves A, B, and C represent total deposition of a mass of sediments equal to two, five, and ten times the existing mass, respectively. The corresponding half-mass ages are 1.4, 0.6, and 0.3 billion years. Hachured histogram is an estimate of the actual mass distribution based on observed occurrence (*1*) and our interpretation of the Precambrian distribution.

Sediments have been continuously deposited and destroyed throughout geologic time. The rates of deposition and destruction certainly have not been constant, as evidenced today by the irregular distribution of sediment mass as a function of age; however, one can construct highly simplified models in an attempt to simulate the gross aspects of today's mass distribution.

Based on the assumptions of a total mass that is constant with time, constant and equal rates of deposition and destruction, and an equal probability of destruction of equal masses (independent of age) distributions of sedimentary mass as a function of age are predicted (Fig. 1). The 5x model is of the right order of magnitude to fit actuality; the 10x model predicts too small a mass of older sediments, and the 2x model far too much (Fig. 1). The choice of the 5x model, as opposed to either of the others, is compelling. This conclusion would not change even if there were large errors in estimates of the actual age distribution of existing sediments. The mass distribution required to fit the 10x and 2x models is contrary to the experience of many geologists.

Approximately half the total mass of existing sediments is younger than 600 million years, whereas the rest is distributed irregularly over an interval of about 2500 to 3000 million years; that is, the half-mass age of all sedimentary rocks is about 600 million years. However, the half-mass ages of the various components of the sedimentary lithosphere appear to be different; that of carbonate rocks is about 300 to 400 million years and that of evaporites perhaps 200 to 300 million years (Fig. 1) (*2*).

The near absence of evaporite deposits in Precambrian rocks may then be largely attributable to a rapid turnover of these relatively soluble materials. The present mass–age relations indicate that a cycling rate two to three times that of the shales would be sufficient to account for present day distributions. Also, there has long been an apparent discrepancy between the 20 to 30 percent of carbonate rocks in the post-Precambrian record and the 5 to 10 percent predicted for all sedimentary rocks by geochemical balance calculations (*3*). If carbonate rocks cycle approximately 1.5 to 2 times faster than shale, they would be predicted to make up decreasing percentages of existing sedimentary rocks as a function of increasing age, even though their percentage of the total mass may always have been very nearly the same. The predicted present distribution of shale, carbonate, and evaporite as a function of age (Fig. 2) based on half-mass ages of 600, 300, and 200 million years, respectively, agrees favorably with the actual distribution (*2*). Finally, the possibility emerges that the very large percentages of cherty rocks, particularly of middle Precambrian age, may reflect the slow cycling of chert because of its high resistance to erosion and its characteristic protected position at the bottom of sedimentary basins.

From these qualitative relations we suggest that geochemical "uniformitarianism" should be strongly consid-

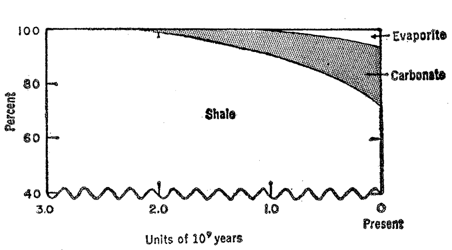

Fig. 2. Calculated present distribution of shale, carbonate, and evaporite as a function of time. The calculation is based on half-mass ages of shale, carbonate, and evaporite of 600, 300, and 200 million years, respectively.