

**BRITISH MUSEUM NATURAL
RADIOCARBON MEASUREMENTS X**

RICHARD BURLEIGH, ANDREW HEWSON, and NIGEL MEEKS
Research Laboratory, The British Museum, London WC1B 3DG

GALE SIEVEKING and IAN LONGWORTH
Department of Prehistoric and Romano-British Antiquities,
The British Museum, London WC1B 3DG

The following list consists entirely of dates for archaeological samples from the prehistoric flint mining site of Grime's Graves, Weeting, Thetford, Norfolk, England (52° 30' N, 0° 40' E, Natl Grid Ref TL 816898), measured over the period from August 1973 to December 1977,* all the samples having been excavated between 1972 and 1976. The dates were obtained by liquid scintillation counting of benzene using a Model 3315 Packard Tricarb Liquid Scintillation Spectrometer linked to a Hewlett Packard 2100A computer system for on-line processing of counting data (Hall & Hewson, 1977). The laboratory procedures used were those outlined in the two previous lists (R, 1976, v 18, p 16; 1977, v 19, p 143).

Antler and bone samples were demineralized with 1 N hydrochloric acid at about 20°C to provide pure collagen for ¹⁴C age measurement; charcoal samples were pretreated by prolonged boiling in dilute hydrochloric acid. The highly calcareous environment in which these materials had been buried precluded contamination by humic acids and no pre-treatment with alkali was needed.

The dates are expressed in radiocarbon years relative to AD 1950, based on the Libby half-life for ¹⁴C of 5570 years, and are corrected for isotopic fractionation ($\delta^{13}\text{C}$ values are relative to PDB). No corrections have been made for natural ¹⁴C variations. The modern reference standard was NBS oxalic acid. Errors are based on counting statistics alone and are equivalent to ± 1 standard deviation ($\pm 1\sigma$).

The British Museum excavation at Grime's Graves from 1972-1976 has provided a unique opportunity for interdisciplinary study of the problems of dating a large prehistoric industrial site by the radiocarbon method. Previous excavations (Clarke, 1915; Greenwell, 1871) had shown that picks made from the antlers of red deer (*Cervus elaphus*) were used by the prehistoric miners at Grime's Graves as at other flint mines in S England. The picks were preserved in large numbers in the chalk fill of galleries, shafts and other workings. A number of picks from the excavations of A L Armstrong, who worked at Grime's Graves between ca 1920 and the mid-1930's, were held in the Museum's collections. These and well-provenanced specimens from other archaeological excavations had already been used to provide a general framework of 17 radiocarbon dates for Grime's Graves and flint mines on the S coast of England

* Dates obtained over part of the same period for archaeological sites other than Grime's Graves formed the previous two lists, British Museum VIII and IX; further dates for other sites obtained during this time will form the next two lists, British Museum XI and XII.

and on Salisbury Plain (R, 1961, v 3, p 41; 1963, v 5, p 106; 1969, v 11, p 285; Burleigh, 1975). Excavation of a shaft at Grime's Graves in 1971-1972 yielded 7 more samples of antler and charcoal which provided dates in good general agreement with those for the material from the earlier excavations (R, 1976, v 18, p 32; Mercer, 1976; Sieveking *et al*, 1973). The radiocarbon determinations suggested that flint mining at Grime's Graves dated to the period around 4000 yr BP, confirming the accepted view that exploitation of the site did not pre-date the Neolithic period (Clark & Piggott, 1933; Piggott, 1954). The other British flint mines appeared to be up to 1000 yr earlier, suggesting that mining had moved to E Anglia after the mines on the S coast and perhaps those on Salisbury Plain had been abandoned. Questions which still remained unanswered were the extent to which the available dates represented the total period of mining at Grime's Graves and the possibility that mining had been renewed at a later period as the presence of pottery and other occupation debris of recognizably later date suggested.

The scale of the excavation and dating problems at Grime's Graves may be judged from a brief description of the site. Over the area of some 37 ha which the site occupies many different methods of exploitation of flint are represented. More than 350 infilled large-scale shaft and gallery mines have been located although only ca 20 of these have been explored to any extent. Typically, the shafts of these mines are 4 to 8m in diam at the surface and 5 to 14m in depth. Low horizontal galleries radiate from the base of each shaft, often interconnecting with the galleries of adjacent shafts. Open-cast mining in the form of smaller pits, 2 to 4m in diam and 2 to 3m in depth, also now infilled, occupies a large area, and different parts of the site may have been exploited sequentially. Accompanying and sometimes overlying the underground workings are surface layers, some containing the abundant debris of flint workshops and some containing habitation debris, not necessarily related to industrial activity. To gain an overall picture of the sequence and intensity of mining and industrial activity at Grime's Graves, radiocarbon samples were taken from every type of underground and surface working investigated and from workshop and habitation areas on different parts of the site.

For the purposes of this date list the radiocarbon determinations have been grouped into broad classes as follows:

- I. Early occupation sites. Pits containing occupation debris unrelated to and antedating flint mining and workshop activity.
- II. Galleried mines. Shafts cut into solid chalk to reach deep layers of tabular flint.
- III. Open-cast mines. Workings of two main types comprising small pits cut into cryoturbated chalk and till, and trial pits cut into undisturbed chalk, both in search of localized supplies of nodular flint.
- IV. Industrial debris. Flint workshops, both small and large-scale.

I. EARLY OCCUPATION SITES

Lab no.	Grid ref	Feature	Material	Date BP	Date BC	$\delta^{13}\text{C} \text{‰}$
BM-990	880/910	1b	Charcoal	7614 \pm 80	5664	-24.90
BM-989	900/870	5c	Charcoal	8519 \pm 309	6569	-21.60

II. GALLERIED MINES

Lab no.	Shaft	Gallery	Material	Date BP	Date BC	$\delta^{13}\text{C} \text{‰}$
BM-973	15A	31-32	Antler	3827 \pm 45	1877	-24.20
BM-997	15A	57-58	Antler	3960 \pm 56	2010	-24.90
BM-975	15B	19-20	Antler	3940 \pm 41	1990	-24.10
BM-1051	15B	19-20	Antler	3887 \pm 56	1937	-23.20
BM-1003	15B	31-32	Antler	3949 \pm 42	1999	-22.50
BM-1052a	15B	31-32	Antler	4114 \pm 45	2164	-22.90
BM-1052b	15B	31-32	Antler	3954 \pm 43	2004	-22.90
BM-996	15B	57-58	Antler	3890 \pm 42	1940	-23.60
BM-1053	15B	57-58	Antler	3834 \pm 50	1884	-23.30
BM-974	15C	57-70	Antler	3887 \pm 47	1937	-24.10
BM-1054	15C	57-70	Antler	3904 \pm 36	1954	-22.20
BM-980	15D	37-38	Antler	3736 \pm 58	1786	-24.80
BM-1056a	15D	37-38	Antler	3838 \pm 42	1888	-23.80
BM-1056b	15D	37-38	Antler	3740 \pm 48	1790	-23.80
BM-978	15D	79-80	Antler	3865 \pm 44	1915	-25.00
BM-1011	15D	79-80	Antler	3952 \pm 44	2002	-22.50
BM-1057	15D	79-80	Antler	3924 \pm 47	1974	-23.00
BM-972	15D	79-80	Charcoal	3071 \pm 209	1121	-27.40
BM-1260	15D	516-517	Antler	4037 \pm 62	2087	-22.50
BM-1262	15D	516-517	Charcoal	3900 \pm 54	1950	-24.70
BM-1002	15E	59-60	Antler	3882 \pm 45	1932	-21.20
BM-1058	15E	59-60	Antler	3876 \pm 48	1926	-22.90
BM-998	15E	61-62	Antler	3992 \pm 45	2042	-23.00
BM-977	15F	59-60	Antler	4015 \pm 61	2065	-24.50
BM-1059	15F	59-60	Antler	3977 \pm 47	2027	-22.60
BM-1000a	15G shaft	—	Antler	4051 \pm 109	2101	-23.20
BM-1000b	15G shaft	—	Antler	4022 \pm 57	2072	-23.20
BM-976	15G	75-76	Antler	3849 \pm 44	1899	-23.00
BM-979	15J	79-80	Antler	3820 \pm 46	1870	-25.00
BM-1001	15J	79-80	Antler	3868 \pm 56	1918	-23.30
BM-971	15J	79-80	Charcoal	3868 \pm 66	1918	-25.80
BM-986	15J	79-80	Charcoal	3845 \pm 44	1895	-25.90
BM-1027	Greenwell	101-102	Antler	3855 \pm 36	1905	-23.00
BM-1261	Greenwell	101-102	Antler	3853 \pm 71	1903	-21.40
BM-1049	Greenwell	104-107	Antler	3884 \pm 43	1934	-22.10

II. GALLERIED MINES (continued)

Lab no.	Shaft	Gallery	Material	Date BP	Date BC	$\delta^{13}\text{C} \text{‰}$
BM-1028	Greenwell	108-109	Antler	3922 ± 38	1972	-19.50
BM-1044	Greenwell	108-109	Antler	3922 ± 86	1972	-22.30
BM-1048	Greenwell	108-109	Antler	3880 ± 38	1930	-21.60
BM-1050	Greenwell A	200-201	Antler	3893 ± 44	1943	-21.70
BM-1068	Greenwell A	200-201	Antler	3784 ± 50	1834	-22.10
BM-1029	Greenwell C	105-106	Antler	3859 ± 53	1909	-22.40
BM-1045	Greenwell C	105-106	Antler	3949 ± 41	1999	-23.30
BM-1047	Greenwell C	105-106	Antler	3974 ± 45	2024	-22.60
BM-1046	Greenwell C	in gallery	Antler	3797 ± 52	1847	-20.30
BM-981	11A	in gallery	Antler	3874 ± 47	1924	-22.80
BM-982	11B/E	in gallery	Antler	4090 ± 58	2140	-21.00
BM-987	11B/E	in gallery	Charcoal	3671 ± 75	1721	-26.00
BM-983	11D	in gallery	Antler	3761 ± 48	1811	-21.70
BM-984	11E	in gallery	Antler	3902 ± 58	1952	-23.10
BM-985	11F	in gallery	Antler	4010 ± 59	2060	-23.00
BM-1020	2	in gallery	Antler	3844 ± 221	1894	-23.00
BM-1069	2	in gallery	Antler	3896 ± 141	1946	-22.00

III. OPEN-CAST MINES

Lab no.	Grid ref	Feature	Material	Date BP	Date BC	$\delta^{13}\text{C} \text{‰}$
(a) Small pits						
BM-970	955/820	3	Antler	3767 ± 57	1817	-24.90
BM-1019	950/820	4	Antler	3593 ± 45	1643	-23.20
BM-992	955/820	5	Antler	3727 ± 57	1777	-23.20
BM-993	955/820	6	Antler	3614 ± 67	1664	-23.50
BM-1007	950/820	6	Antler	3825 ± 54	1875	-23.30
BM-1016	950/820	11	Antler	3797 ± 49	1847	-20.60
BM-1005	950/820	12	Charcoal	3948 ± 37	1998	-24.70
BM-1015	950/820	14	Antler	3851 ± 34	1901	-22.20
BM-1017	950/820	16	Antler	3710 ± 39	1760	-23.10
BM-1063	953/850	28	Antler	3874 ± 55	1924	-22.10
BM-1062	961/861	34	Antler	3695 ± 49	1745	-22.90
(b) Trial pits and mines						
BM-1060	—	Pit 3A	Antler	3863 ± 86	1913	-23.50
BM-1009	950/820	7	Antler	3825 ± 41	1875	-20.60
BM-1010	950/820	14	Antler	3770 ± 66	1820	-21.50
BM-1008	950/820	24	Antler	3764 ± 39	1814	-23.10
BM-1061	952/964	105	Antler	3666 ± 55	1716	-22.00

IV. INDUSTRIAL DEBRIS

Lab no.	Grid ref	Feature	Material	Date BP	Date BC	$\delta^{13}\text{C} \text{‰}$
(a) Small scale						
(i) Early group						
BM-1023	950/820	18	Charcoal	4061 ± 52	2111	-24.30
BM-1012	950/820	19	Antler	3695 ± 33	1745	-22.90
BM-1064	950/860	32	Antler	3748 ± 59	1798	-22.80
BM-1024	950/820	36	Charcoal	3904 ± 38	1954	-18.60
BM-1006	950/820	38	Charcoal	4017 ± 60	2067	-25.10
BM-1066	1195/945	Trench 2	Charcoal	4224 ± 74	2274	-24.70
(ii) Late group						
BM-812	1000/910	(1972)	Antler	3380 ± 55	1430	-26.60
BM-1030	950/950	106	Charcoal	2953 ± 36	1003	-25.80
BM-1032	940/940	112	Charcoal	3286 ± 67	1336	-20.10
(b) Large scale						
BM-995	1267/906	—	Charcoal	3947 ± 66	1997	-25.30
BM-988	1255/905	—	Charcoal	3755 ± 259	1805	-25.00
BM-1013	1255/905	L6 baulk	Charcoal	3929 ± 49	1979	-27.00
BM-1014	1266/900	—	Charcoal	3813 ± 43	1863	-25.80

V. OCCUPATION DEBRIS

Lab no.	Grid ref	Feature	Material	Date BP	Date BC	$\delta^{13}\text{C} \text{‰}$
(a) Minor features						
BM-811	1000/905	(1972)	Charcoal	3607 ± 300	1657	-27.20
BM-991	900/870	2	Charcoal	3414 ± 46	1464	-24.10
BM-994	955/820	7	Charcoal	3535 ± 90	1585	-25.10
BM-1022	950/820	13	Charcoal	3559 ± 39	1609	-24.90
BM-1018	950/820	23	Antler	3593 ± 37	1643	-21.70
BM-1033	940/950	121	Charcoal	2881 ± 49	931	-25.60
BM-1034	960/940	124	Charcoal	3763 ± 47	1813	-25.80
BM-1065	1274/1022	Trench 3	Charcoal	3941 ± 89	1991	-24.60
(b) Occupation debris with Bronze Age pottery						
(i) Minor features						
BM-1031	950/950	108	Charcoal	3386 ± 41	1436	-24.90
(ii) Shaft X, 1270/900 (1270/905, 1275/900, 1275/905)						
BM-1035	L14 m.sq.G		Charcoal	2994 ± 40	1044	-25.50
BM-1039	L20 m.sq.M		Charcoal	2806 ± 54	856	-25.00
BM-1040	L20a m.sq.D		Charcoal	2905 ± 54	955	-25.00
BM-1036	L19 m.sq.G		Charcoal	2995 ± 39	1045	-25.50
BM-1041	L19a m.sq.C		Charcoal	3573 ± 57	1623	-25.20
BM-1042	L19b m.sq.H		Charcoal	2919 ± 53	969	-24.70

V. OCCUPATION DEBRIS (continued)

Lab no.	Grid ref	Feature	Material	Date BP	Date BC	$\delta^{13}\text{C} \text{‰}$
BM-1043	L19c	m.sq.H	Charcoal	2838 ± 53	888	-24.80
BM-1265	L4	m.sq.BCDFGH	Charcoal	2800 ± 79	850	-24.20
BM-1038	L5	m.sq.A	Charcoal	2936 ± 43	986	-24.80
BM-1266	L6	m.sq.K	Charcoal	2834 ± 53	884	-24.70
BM-1037	L9	m.sq.JMN	Charcoal	3003 ± 49	1053	-21.40
BM-1263	L4	m.sq.L	Charcoal	3443 ± 53	1493	-24.80
BM-1264	L10	—	Charcoal	3154 ± 64	1204	-24.90

VI. BONE ANALYSIS

Lab no.	Grid ref	Feature	Material	Date BP	Date BC	$\delta^{13}\text{C} \text{‰}$
BM-1067	940/950	123	Bone	2559 ± 80	609	-21.90

V. Occupation debris. Hearth material, either *in situ* or redeposited in rubbish pits, with assoc fragments of pottery, stone tools or in some instances with metal tools, but not assoc with workshop debris.

VI. Bone analysis.

The ordering of dates within these classes is as follows: For the deep mines (Pit 15, Greenwell's pit, Pit 11 and Pit 2, respectively) dates are listed in shaft and gallery order. In the other 5 classes, the dates are listed in Feature no. order, with the exception of dates for Shaft X (V, Occupation debris) which are listed in stratigraphic order. In all classes dates for antler precede dates for charcoal from the same provenance. The point of origin of the grid system used for the Grime's Graves excavation is Base Reference Peg 1000/1000 (Sieveking *et al*, 1973, fig 6, p 194).

In summary, the evidence newly available from Grime's Graves suggests that the large-scale exploitation of flint by means of galleried mines dates to a relatively short period between ca 2100 to 1800 bc, while open-cast quarrying continued until ca 1650 bc. There is some evidence for intermittent occupation on the site, with tool manufacture, between this date and the intensive Bronze Age occupation, not related to flint extraction, beginning ca 1000 bc. No evidence was found for an early mining period antedating the galleried mines.

A full discussion and interpretation of the dates will appear as one of the fascicles (Burleigh & Sieveking, ms in preparation) in a series to be published by the British Museum on the recent excavations at Grime's Graves. Finally, brief reference should be made to 2 other aspects of the radiocarbon dating relating to Grime's Graves. These are, firstly, the evidence for very short-term natural ^{14}C variations provided by radiocarbon dates for antlers from the deep mines (Burleigh & Hewson, 1976;

1978), and secondly, the dating of the skull and skeleton of a domestic dog found in gallery 104-107 of Greenwell's pit, I of only 3 complete examples known from the Neolithic period in Britain (Burleigh *et al*, 1977).

ACKNOWLEDGMENTS

We thank the Trustees of the British Museum for provision of funds for excavation at Grime's Graves from 1972-1976. Permission to carry out the excavation was granted by the Inspectorate of Ancient Monuments, Department of the Environment. The galleries of the deep mines were excavated by members of the Prehistoric Mining Workgroup of the Dutch Geological Association (Maastricht).

REFERENCES

- Burleigh, R, 1975, Radiocarbon dates for flint mines, *in*: 2nd internatl symposium on flint, Maastricht, Netherlands, 8-11 May, 1975: Maastricht, Nederlandse Geol Vereniging (Staringia No. 3), p 89-91.
- Burleigh, R, Clutton-Brock, J, Felder, P J, and Sieveking, G de G, 1977, A further consideration of Neolithic dogs with special reference to a skeleton from Grime's Graves (Norfolk), England: *Jour Archaeol Sci*, v 4, p 353-366.
- Burleigh, R and Hewson, A, 1976, Evidence for short term atmospheric ^{14}C variations about 4000 yr BP: *Nature*, v 262, p 128-130.
- 1978, Archaeological evidence for short-term natural ^{14}C variations, *in*: Berger, R and Suess, H (eds), 9th internatl conf on radiocarbon dating Proc, Los Angeles and La Jolla, California, 20-26 June, 1976: Los Angeles, Univ California Press (in press).
- Clark, J G D and Piggott, S, 1933, The age of the British flint mines: *Antiquity*, v 7, p 166-183.
- Clarke, W G (ed), 1915, Report on the excavations at Grime's Graves, Weeting, Norfolk, March-May, 1914: *Prehist Soc E Anglia*, Research rept, p 1-254.
- Greenwell, W, 1871, On the opening of Grime's Graves in Norfolk: *Jour Ethnol Soc*, v 2, p 419-440.
- Hall, J A and Hewson, A, 1977, On-line computing and radiocarbon dating at the British Museum: *Jour Archaeol Sci*, v 4, p 89-94.
- Mercer, R J, 1976, Grime's Graves, Norfolk — an interim statement on conclusions drawn from the total excavation of a flint mine shaft and a substantial surface area in 1971-72, *in*: Burgess, C and Miket, R (eds), Settlement and economy in the third and second millennia BC (British archaeol repts 33): Oxford, BAR, p 101-111.
- Piggott, S, 1954, *The Neolithic cultures of the British Isles*: Cambridge, Cambridge Univ Press.
- Sieveking, G de G, Longworth, I H, Hughes, M J, Clark, A J, and Millet, A, 1973, A new survey of Grime's Graves, Norfolk: *Prehist Soc Proc*, v 39, p 182-218.