RADIOCARBON DATES OF ARCHAEOLOGICAL SAMPLES

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IN this paper are reported the measured *radiocarbon dates* of several archæological samples using the acetylene synthesis method (Suess, 1954). The techniques used for the measurement of radiocarbon activity of samples and the principle of radiocarbon method, developed by Libby and his co-workers, have been dealt with in some detail in a previous publication from this laboratory (Kusumgar *et al.*, 1963 *a*).

The *radiocarbon dates* are calculated on the basis of a 95% net activity of the oxalic acid standard, supplied by the National Bureau of Standards, as the age-corrected value for pre-1900 wood. This standard has been internationally accepted by most radiocarbon laboratories (Godwin, 1959).

Two dates are given for each sample. The first date is based on the value of 5568 ± 30 yrs. for the half-life of radiocarbon ; the second date, given within parenthesis, is calculated on the basis of a recently measured half-life value, 5730 ± 40 yrs. Though the latter seems to be a better working value, as discussed at the Vth International Radiocarbon Conference (Godwin, 1962), no international agreement has been reached as yet on a final half-life value. It is important that all intercomparisons should be based on dates calculated using a particular half-life value only. All dates given are in years B.P. ; for converting them to A.D./B.C.; 1950 A.D. should be used as the reference year (Flint *et al.*, 1962).

All samples were given an initial treatment before processing through various chemical steps for the synthesis of acetylene from the sample carbon in order to remove extraneous intrusions. The samples were carefully inspected and cleaned of foreign objects such as mud grains, rootlets, etc. The samples were then treated with dilute HCl and subsequently boiled in a dilute NaOH solution to get rid of any humic acid present. NaOH pretreatment was avoided when the sample was too soft and expected to disintegrate.

The sites from where the samples* derived have been arranged in an alphabetical order. Where more than one sample was measured from the same site, the samples have been described in the order of increasing archæological ages. Approximately contemporary samples have been arranged on the basis of increasing C^{14} dates only.

A Brief Discussion of Dates

A large number of samples have been measured from Hastinapur. The C^{14} dates for the P.G. Ware Culture are in good agreement with Wheeler's date bracket of *ca.* 800–500 B.C. (Wheeler, 1959), thus falling little short of Lal's estimate (Lal, 1954, 1955). More measurements are, however, necessary to define the time-spread of P.G. Ware.

Two samples from Kausambi appear to be systematically younger by a couple of hundred years compared to archæological estimates.

The date on one sample from Mohenjodaro is in good agreement with the archæological estimate (Piggot, 1961). Similarly, the single date for Kudan is also in good agreement. For Rajar Dhibi no definite basis for archæological dating exists. The solitary dated sample, deriving from the latest period of the site, will have to be followed up by a number of measurements to define the chronological frame-work for the site.

The remaining dates are for samples deriving from Nagarjunakonda, Adichanallur, Mohanur and Alamgirpur. Except for the Adichanallur sample (wood) which was kept impregnated with wax in the museum for *ca.* 60 years, others are bones. All the C^{14} dates for these samples are in complete disagreement with the archæological estimates. The work of several radiocarbon laboratories has shown that radiocarbon dates of bone samples are usually not reliable as their carbon is easily exchanged by the passage of substratum water containing dissolved limestone or atmospheric carbon-dioxide. Furthermore, the samples in question were not specifically collected for radiocarbon dating and some doubt has been expressed by archæologists as regards to their identity.

A list of all dates measured prior to this work has already been published (Kusumgar *et al.*, 1963 *b*). It is proposed that as and when sufficient new radiocarbon dates of the Institute become available, they will be periodically presented in this journal. An annual compilation of all dates is submitted regularly

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* Samples for radiocarbon dating are accepted by the Radiocarbon Laboratory of the Institute which has been set up primarily as a national facility for archæological research. All enquiries should be addressed to the Secretary, Radiocarbon Dating Committee, Tata Institute of Fundamental Research, Colaba, Bombay-5.

to the journal *Radiocarbon* where dates from all radiocarbon labolatories are published.

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C^{14} DATES WITH SAMPLE DESCRIPTIONS

Adichanallur, Madras, India

TF-70 Burials, 775 ± 95 (795 ± 95)

Wood sample from Adichanallur (Lat. 8° 50′ N., Long. 76° 40′ E.), Tinnevelly District, Madras. The site was excavated during 1899-1905. The sample had been stored after soaking in wax. Sample submitted by Shri Satyamurti. Wood pieces were boiled in hot water. NaOH pretreatment was also given.

The date obtained is in wide divergence from the archæological estimates, as the sample is supposed to be associated with urn-burials.

Alamgirpur, U.P., India

TF-51 Bone Sample, 1060 ± 95 (1090 ± 100)

A composite of three samples believed to have been derived from the P.G. Ware deposit of the site, Alamgirpur (Lat. 30° 45′ N., Long. 75° 50′ E.), District Meerut, U.P. Sample was submitted by Shri A. Ghosh.

The date obtained is at considerable variance with the archæological estimate. Because such a large contamination is unlikely and also as from the sections the samples appear to belong to disturbed strata, the possibility of a wrong identification of the levels cannot be ruled out.

Hastinapur, Uttar Pradesh, India

Hastinapur (Lat. 29° 9′ N., Long. 78° 3′ E.) is located on the left bank of Ganga River in Meerut District. The site was excavated by Shri B. B. Lal, Director, School of Archæology, in 1950-52 and 1962. The samples presented in this paper belong to the Periods II and III of the site. The excavator has suggested an association of Aryans with the P.G. Ware industry of Period II. Samples submitted by Shri A. Ghosh.

The five dates presented here have an internal consistency borne out by the stratigraphic sequence of the site. The C^{14} measurements suggest the spread of Period III between *ca.* 400 and *ca.* 100 B.C. And there does not appear much gap between the end of Period II and the beginning of Period III. It is highly desirable to obtain more C^{14} measurements for these crucial periods in Indian archæology to define the chronologies of N.B.P. and P.G. Wares.

TF-80, 82, Period III, 1940 ± 110 (2000 ± 110)

A composite of two samples of charcoal (mixed with earth) from Trench HST-1/1962 (Northern extension), Locus G-H, Layer 23, Field Nos. HST/62/C/1 and 4, Depth 3·9 m. below surface. The samples derived from identical depths and layers. The sample is believed to belong to the end of Period III.

TF-88, Period III, 2225 ± 110 (2290 ± 110)

Charcoal sample (mixed with earth) from Trench HST-1/1962, Locus XCIV-XCVII, Layer 25, Field No. HST/62/C/15, Depth 6·45 m. below surface. The sample is from the lowest layer of Period III which marks the beginning of N.B.P.-ware. (Some rootlets were visible in the sample.)

TF-83, Period II, 2220 ± 110 (2285 ± 110)

Charcoal sample (mixed with earth) from Trench HST 1/1962, Locus XCIV-XCVII, Layer 26, and Pit Y sealed by Layer 25, Field No. HST/62/C/6, Depth 6·75 m. below surface. The sample derives from the uppermost layer of Period II marking the end of Painted Grey-ware. (A few rootlets were visible in the sample.)

TF-90, Period II, 2270 ± 110 (2335 ± 110)

Charcoal (mixed with earth) from Trench HST-1/1962, Locus XCIV-XCVII, Layer 26, Field No. HST/62/C/17, Depth 6·6 m. below surface. The sample is from the same layer as TF-83.

TF-85, Period II, 2385 ± 125 (2455 ± 130)

Charcoal (mixed with earth) from Trench HST-1/1962, Locus XC-XCIV, Layer 28 and Pit Z which is sealed by Layer 27, Field No. HST/62/C/10, Depth 7·25 m. to 7·45 m. below surface. The sample belongs to the late levels of Period II. (A few rootlets visible in the sample.)

Kausambi, Uttar Pradesh, India

Kausambi (Lat. 81° 23′ N., Long. 25° 20′ E.), modern Kosam, is situated on the northern bank of Yamuna. According to the Puranas, the Capital of the Pandavas was shifted from Hastinapur to Kausambi at the time of Nichaksu, fifth in descent from Parikshit, the grandson of Arjuna. The site is being excavated every year since a decade by the Allahabad University under the direction of Prof. G. R. Sharma who submitted these samples.

TF-93. Early Roads, 1655 ± 105 (1705 ± 110)

Charcoal (mixed with earth) from Kausambi, Allahabad District, Trench KSB-I-III-RD, Locus 3-5, Layer 4, Field No. KSB/63/AP-1, Depth 1·25 m. below surface. (A few rootlets were visible in the sample.)

TF-97, Early Road, 1640 ± 105 (1690 ± 110)

Charcoal (mixed with earth) from Trench KSB-I-III-RD, Locus 2-5, Layer 6, Field No. KSB/63/AP-5, Depth 1·65 m. to 1·7 m. below surface. (A few rootlets were visible in the sample.)

Kudan, Nepal

TF-62, Early Medieval Temple, Kudan:

TF-62 *a*, 1020 ± 100 (1055 ± 105)
TF-62 b, 850 ± 95 (875 ± 100)

935 ± 70 (965 ± 75)

Charred wood (mixed with earth) from Kudan (Lat. 27° 32′ N., Long. 83° 2′ E.). Layer 3, Depth 1·55 m., Field No. Kudan D-6, from a temple door-frame. Sample treated with HCl and NaOH. (Some visible rootlets were present in the sample.) Sample submitted by Shri A. Ghosh.

Mohanur, Madras, India

TF-77, Burials, 330 ± 100 (340 ± 105)

Bone sample from Mohanur (Lat. 10° 30′ N., Long. 79° 05′ E.), Salem District. The sample is believed to have derived from the accidental discovery of the "vestigeal urn-burials" on the banks of Kaveri River. Sample submitted by Shri Satyamurti, State Museum, Madras.

Mohenjodaro, West Pakistan

TF-75, Harappa Cultured, 3600 ± 110 (3705 ± 115)

Clean charred grain from Mohenjodaro (Lat. 27° 19′ N., Long. 68° 8′ E.), Sind. Locus: Chamber 60, Block-2, from the pavement of a 'late date', Depth 1·27 m. below datum, Field No. L 855, as recorded in Marshall's report. Since 1925 A.D. the sample was kept in a glass bottle in the Safdarjang collection, New Delhi. Sample submitted by Shri A. Ghosh.

This is the first radiocarbon date for the late Harappan levels of Mohenjodaro.

Nagarjunakonda, Andhra Pradesh, India

The extensive site of Nagarjunakonda (Lat. 16° 31′ N., Long. 79° 14′ N.), is situated in Guntur District. Excavations were conducted by Dr. Subrahmanyam of the Survey during 1954-61 (Ghosh, 1953-61). The samples described below are believed to have all derived from the Neolithic cemetery (*ca.* 2000 B.C.). Samples were submitted by Shri A. Ghosh.

The C^{14} dates obtained are in complete disagreement with the archæological estimates. Reasons for this discrepancy have been discussed in the text.

TF-73 Burials, 1495 ± 105 (1535 ± 110)

Soft and spongy human bones from the Neolithic cemetery. Grave No. 4, Skeleton No. 6, Depth 40 cm. below surface.

TF-72 Burials, 1525 ± 95 (1570 ± 100)

Soft and spongy human bones from the Neolithic cemetery. Grave No. 6, Skeleton No. 8, Depth 52 cm. below surface.

TF-30 Burials, 1535 ± 95 (1580 ± 100)

Animal bones laden with ash from a Neolithic pit No. 44, Site 46, Sector NV, Division 362, Trench A 3, 1·2 m. to 1·5 m. below surface.

TF-63 b *Burials,* 1750 ± 100 (1805 ± 105)

Soft and spongy human bones from the Neolithic cemetery, Grave No. 5, Skeleton No. 7, Depth 35 cm. below surface.

TF-74 Burials, 1900 ± 95 (1955 ± 100)

Soft and spongy human bones from Neolithic cemetery. Grave No. 8, Skeleton No. 10, 50 cm. below surface.

Rajar Dhibi, West Bengal, India

TF-61, Period V, 1230 ± 105 (1260 ± 110)

Charcoal sample (mixed with soil) from Rajar Dhibi (Lat. 23° 34′ N., Long. 87° 39′ E.), from Burdwan District, W.B., Trench No. RDB IV, Locus: O-II, Depth 1 m., Layer 2 C. Submitted by Shri P. Dasgupta.

Sample was also treated with NaOH. (Traces of rootlets were present in the sample.)

This is the first time that the latest period of this culture has been dated. No definite datable archæological evidence seems to be available at present to determine the chronology of these cultures of West Bengal.

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