

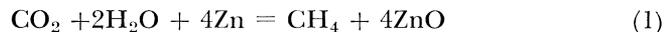
TATA INSTITUTE RADIOCARBON DATE LIST IV

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All measurements reported in the previous date lists (Kusumgar *et al.*, 1963a; Agrawal *et al.*, 1964 and 1965a) were based on acetylene counting. Since September 1964 we have changed over to methane counting and all dates presented here are based on this method. Methane counting offers certain advantages over acetylene, e.g., (1) rapid synthesis, (2) the non-explosive nature of gas, (3) the synthesized gas is radon-free. The disadvantage of having only one atom per molecule in methane (CH₄), as against two in acetylene (C₂H₂), is compensated by the fact that methane can be counted at higher pressures with relatively low operating voltages.

The method of methane synthesis developed by Anand and Lal (1964) for the purposes of counting tritium activity has been adapted by us for the measurement of activity of C¹⁴. The pretreatment and combustion procedures (Kusumgar *et al.*, 1963b) remain unchanged except for the added steps of purification of CO₂ which is now passed through 0.1 N KMNO₄ solution and AgO at 350° C, before letting it through a charcoal-silica-gel trap at room temperature. Sample carbon, after being oxidized to CO₂, is filled in a reaction vessel containing zinc dust, water, and catalyst. Methane is synthesized in the presence of the catalyst (0.5% Ru on Al₂O₃) maintained at 475-510°C. The following effective reaction takes place:



To make the reaction quantitative, 10% excess of water is taken and the yields of methane synthesized are better than 99.9%. Typical proportions of the reactants are: 6.3 L CO₂ (S.T.P.), 11 cc H₂O and 400 g zinc dust. Purification of the gas is then carried out. The procedures for a quantitative extraction and purification of methane have been described in detail elsewhere (Agrawal *et al.*, 1965b).

We have preferred to use the reaction (1) to the one developed by Fairhall *et al.* (1961), as the commercially available hydrogen was found to contain sufficient tritium activity. For reaction (1), we obtained "dead" water from a tubewell in Chanasma (Gujarat).

Two Oeschger-Houtermans gas-proportional counters of 2.7 L volume each are in use. One counter is filled at 115 and the other at 90 cm Hg corresponding to effective amounts of 0.91 and 0.75 gm carbon counted respectively. The background rate for both the counters is 1.5 cpm.

The dates presented here are based on the radiocarbon half-life value of 5568 yr. For conversion to A.D./B.C. scale, A.D. 1950 has been used as reference year.

All samples were pretreated with dil. HCl. NaOH treatment was given to the relatively harder samples, lest they disintegrate.

GENERAL COMMENTS ON DATES

With the availability of a large number of C¹⁴ dates the outlines of a consistent chronological framework are emerging (Agrawal and Lal, in press). (For this discussion C¹⁴ dates based on the half-life value of 5730 yr have been used.) Harappan time-spread seems to be confined to ca. 2300-1750 B.C. (Agrawal, 1964); the Chalcolithic cultures show a time-spread of ca. 1750-1000 B.C.; Painted Grey ware is covered by the maximum bracket of ca. 1000-400 B.C.; N.B.P. ware is bracketed within ca. 450-50 B.C. The southern Neolithic culture begins around ca. 2300 B.C. The Kashmir Neolithic culture shows a spread of ca. 2300-1500 B.C. This absolute chronology has now made it possible to synthesize the data available on the material traits of the protohistoric cultures. Circumstantial evidence, fortified by C¹⁴ dates, indicate (Agrawal, 1966) that the early Aryans are probably to be equated with the Banasians and the P.G. ware with the later wave Aryans.

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SAMPLE DESCRIPTIONS

I. ARCHAEOLOGIC SAMPLES

Ahichchhatra series, Uttar Pradesh

Ahichchhatra (28° 22' N Lat, 79° 7' E Long), Dist. Bareilly, is site of ancient capital of North Panchal. Excavations are being directed by N. R. Banerji. Samples subm. by A. Ghosh, Director General of Archaeol., New Delhi-11.

TF-301. Defences

Charcoal from Locus CXIII-CXIV, Layer 1, depth 0.8 m, Field No. 2 (Defences). Visible rootlets were handpicked. NaOH pretreatment was also given. *Comment:* sample was found in debris just above mud-filling belonging to Phase II of defences.

**2255 ± 105
305 B.C.**

TF-310. N.B.P. ware deposits

Charcoal from highmound, Locus XI-XII, Pit No. 4 sealed by Layer 8A, depth 0.5 m, Field No. 177 (H.M.). *Comment:* red ware of N.B.P.-ware association was found in these deposits.

**2050 ± 90
100 B.C.**

- 2360 ± 105**
410 B.C.
- TF-311. N.B.P. ware deposits**
Charcoal from highmound, Locus IX'-X', Pit No. 5 sealed by Layer 14, depth 3.8 m, Field No. 196 (H.M.). *Comment:* these deposits also yield P.G. ware.
- 2155 ± 100**
205 B.C.
- TF-317. Late P.G. ware deposits (?)**
Charcoal from highmound, Locus X-XI, Layer 15, depth 3.4 m, Field No. 214 (H.M.). *Comment:* sample belongs to disturbed strata.
- Atranjikhhera series, Uttar Pradesh**
- Atranjikhhera (27° 42' N Lat, 78° 44' E Long), Dist. Etah, is very important site for protohistory of Doab, as a distinct pre-P.G. ware black-and-red ware horizon has been established there. Site is being excavated by R. C. Gaur, Aligarh Univ., Aligarh, who subm. the samples.
- 2150 ± 105**
200 B.C.
- TF-283. N.B.P. ware deposits**
Charcoal from Trench ARJ-4, Locus A₁ (NE), Layer 27, depth 4.85 m, Field No. ARJ-4/64-1.
- 2180 ± 95**
230 B.C.
- TF-284. N.B.P. ware deposits**
Charcoal from Trench ARJ4, Locus A₁ (SW), Layer 29, depth 5.0 m, Field No. ARJ4/64-2. NaOH pretreatment was also given.
- 2410 ± 85**
460 B.C.
- TF-194. Period III**
Charcoal from Trench ARJ4, Locus A₁ (NW), Layer 16, depth 3.10 m, Field No. ARJ-4-A1 (NW).
- 1605 ± 95**
A.D. 345
- TF-287. P.G. ware deposits (?)**
Charcoal from Trench ARJ4, Locus E₂ (NW), Layer IV, depth 1.34 m, Field No. ARJ 4/64-5. Visible rootlets were handpicked. *Comment:* site is disturbed by later floods; sample seems to be a later intrusion.
- 2415 ± 100**
465 B.C.
- TF-291. P.G. ware deposits**
Charcoal from Trench ARJ4, Locus D1 (SE), Layer 6, depth 2.50 m, Field No. ARJ 4/64-9. *Comment:* sample belongs to late levels.
- 2550 ± 105**
600 B.C.
- TF-289. Black-and-red ware deposits**
Charcoal (coated with mud) from Trench ARJ4, Locus E1 (SW), Layer 4, depth 0.95 m, Field No. ARJ4/64-7. NaOH pretreatment was also given.

270 ± 120

TF-187. Baghai Khor, India, rock-shelters **A.D. 1680**

Charcoal from Baghai Khor, Dist. Mirzapur, Trench BGK-Tr.3, Locus 2-3, Pit A sealed by Layer 1, depth 0.1 m, Field No. BGK (M) -63/3001. NaOH pretreatment was also given. Subm. by G. R. Sharma, Inst. of Archaeol., Allahabad Univ., Allahabad. *Comment* (G. R. Sharma): as these shelters have been used to light fires by shepherds till modern times, later intrusions cannot be ruled out. This charcoal is obviously much later.

Bainapalli series, Madras

Bainapalli (12° 33' N Lat, 78° 27' E Long), Dist. North Arcot, is megalithic-Neolithic site of S. It is being excavated by S. R. Rao. Samples subm. by A. Ghosh.

2265 ± 100

TF-350. Post-megalithic period **315 B.C.**

Charred grain from Trench BNPI, Locus C1, Pit 4, sealed by Layer 3, depth 1.30 m, Field No. BNP 1/C₁/64-2. Visible rootlets were hand-picked.

3340 ± 100

TF-349. Neolithic period **1390 B.C.**

Charcoal from Trench BNPI, Locus A1, Layer 6, depth 1.80 m, Field No. BNPI/A₁/64-1. NaOH pretreatment was also given.

2180 ± 105

TF-254. Besnagar, India, N.B.P. ware deposits **230 B.C.**

Charcoal from Besnagar (23° 32' 30" N Lat, 77° 48' E Long), Dist. Vidisha, Trench BSN-1, Locus G1-G2, Layer 8, depth 2.7 m, Field No. BSN-1/G1/C/64-2. Sample subm. by A. Ghosh.

Bahaja series, Maharashtra

Bhaja (18° 44' N Lat, 73° 29' E Long), Dist. Poona, is famous for its early Buddhist rock-excavations. Wooden rafters (though non-functional) have been used on the "roofs." *Comment*: both samples part of much later repairs.

75 ± 90

TF-245. Buddhist rock excavations **A.D. 1875**

Wood from Bhaja rock-excavations, Field No. AR-11. Subm. by A. Ghosh.

350 ± 115

TF-170. Buddhist rock excavations **A.D. 1600**

Wood from girders of the "roof." NaOH pretreatment was also given. Sample subm. by K. A. Chowdhury, Aligarh, Univ., Aligarh.

3670 ± 90**TF-129. Burzahom, India, Neolithic culture****1720 B.C.**

Charcoal from Burzahom (34° 10' N Lat, 74° 54' 30" E Long), Dist. Srinagar, Trench No. BZH-1 (N. Ext.), Locus XIX_x-XXII_x, Layer 13, depth 2.9 m, Field No. BZH-1/62. Sample subm. by A. Ghosh.

Chirand series, Bihar

Chirand (25° 45' N Lat, 84° 45' E Long), Dist. Saran, is well-known protohistoric site of Eastern India. Site is being excavated by B. S. Verma. B.P. Sinha, Dir. of Archaeol., Bihar, subm. the samples. *Comment*: "dates" show possibility of this black-and-red ware being derived from Banas culture via central India.

2640 ± 95**TF-336. Black-and-red ware deposits****690 B.C.**

Charcoal from Trench CRD-VIIB, Layer 14, depth 8.5 m. *Comment*: sample belongs to Period IB, characterized by the advent of iron.

2715 ± 120**TF-334. Black-and-red ware deposits****765 B.C.**

Charcoal from Trench CRD-VIIB, Layer 18, depth 12.5 m. Visible rootlets were handpicked. *Comment*: sample belongs to Period IA.

Dharnikota series, Andhra Pradesh

Dharnikota (16° 34' 45" N Lat, 80° 24' 21" E Long), Dist. Guntur, is an early historic site near Amravati. Excavations were conducted by Venkatramayya and samples subm. by A. Ghosh. *Comment*: TF-248, TF-247 and TF-246 gave dates as expected. But TF-250, which derived from a disturbed pit, gave more activity than the modern standard.

2095 ± 100**TF-248. Fortifications****145 B.C.**

Charcoal from Trench DKT-1, Locus XXXVI-XXXIX, Layer 10, depth 6 m, Field No. DKT-1/63/No. III. *Comment*: sample will date the Satvahana fortifications.

2275 ± 100**TF-247. Early historic period****325 B.C.**

Charcoal from Trench DKT-2, Locus A₂-A₃, Layer 8, depth 3.7 m, Field No. DKT-2/63/No. I. NaOH pretreatment was also given.

2355 ± 95**TF-246. Early historic period****405 B.C.**

Charcoal from Trench DKT-1, Locus XXXVI-XLII, Layer 11, depth 6.5 m, Field No. DKT-1/63/No. II.

Kakoria series, Uttar Pradesh

Kakoria (25° 3' N Lat, 83° 11' E Long), Dist. Varanasi, is the well-known pre-iron megalithic site of Doab. G. R. Sharma subm. the samples.

Comment: the megalithic habitation area is full of thick black "Palash" roots which when dry are quite often mistaken for charcoal. Samples are expected to belong to 1st millennium B.C., but modern ages of the sample counted show that recent black roots were mistaken for charcoal.

TF-179. Megalithic habitation area **195 ± 90**
A.D. 1755

Charcoal from megalithic habitation area. *Comment:* to cross-check this divergent age two more samples, TF-178 and TF-180, were counted; these gave more activity than the oxalic standard. This confirms that modern black roots were mistaken for charcoal.

Kalibangan series, Rajasthan

Kalibangan (29° 25' N Lat, 74° 05' E Long), Dist. Sri Ganganagar, was a provincial capital of Harappa culture. Site also yields remains of pre-Harappa culture. Excavations are being jointly conducted by B. B. Lal and B. K. Thapar. Samples subm. by A. Ghosh. *Comment:* Kalibangan provides an interesting site for study of role of soil cover in contamination. Whenever proper soil cover was not available, samples have given slightly younger ages.

TF-138. Harappa culture **3075 ± 100**
1125 B.C.

Charcoal from Trench KLB-2, Locus A7, Layer 3, depth 0.9 m, Field No. KLB-2, A7/C/1962-63-1. *Comment:* sample derives from uppermost levels of the mound. Whether younger age is due to contamination or some later occupation is not clear.

TF-244. Harappa culture **3250 ± 90**
1300 B.C.

Charcoal from Trench KLB-2, Locus E2, Layer 2, depth 0.35 m, Field No. KLB-2, E2, Qd.4/C/1963-64-4. *Comment:* sample derived from uppermost levels of the mound. Whether younger age is due to contamination or some later occupation is not clear.

TF-143. Harappa culture **3510 ± 110**
1560 B.C.

Wood from Trench KLB-2, Locus YA1, Layer 2, depth 0.25 m, Field No. KLB-2, YA1/C/1962-63-8.

TF-152. Harappa culture **3615 ± 85**
1665 B.C.

Charcoal from Trench KLB-2, Locus XB9, Layer 5, depth 0.90 m, Field No. KLB-2, XB9/C/1962-63-18. NaOH pretreatment was also given.

TF-142. Harappa culture **3635 ± 100**
1685 B.C.

Charcoal from Trench KLB-2, Locus XB8, Layer 4, depth 1.15 m, Field No. KLB-2, XB8/C/1962-63-7.

- 3675 ± 140**
1725 B.C.
- TF-149. Harappa culture**
Charcoal from Trench KLB-2, Locus ZE1, Layer 3, depth 0.65 m, Field No. KLB-2, ZE1/C/1962-63-15. NaOH pretreatment was also given.
- 3705 ± 110**
1755 B.C.
- TF-141. Harappa culture**
Charcoal from Trench KLB-2, Locus A7, Layer 7, depth 1.64 m, Field No. KLB-2, A7/C/1962-63-6.
- 3910 ± 110**
1960 B.C.
- TF-153. Harappa culture**
Charcoal from Trench KLB-2, Locus XB7, Hearth sealed by Layer 1, depth 0.25 m, Field No. KLB-2, XB7/C/1962-63-20.
- 4195 ± 115**
2245 B.C.
- TF-155. Pre-Harappa culture**
Charcoal from Trench KLB-1, Locus ZB2, Layer 9B, depth 3.40 m, Field No. KLB-1, ZB2/C/1962-63-3. *Comment* (B.K.T.): stratigraphy is, however, uncertain.
- 3610 ± 110**
1660 B.C.
- TF-240. Pre-Harappa culture**
Charcoal from Trench KLB-1, Locus XD1, Pit 3 sealed by Layer 3, depth 2.50 m, Field No. KLB-1, XD1, Qd.1/C/1963-64-1. NaOH pretreatment was also given. *Comment*: date is younger than expected archaeologically.
- 3740 ± 105**
1790 B.C.
- TF-156. Pre-Harappa culture**
Charcoal from Trench KLB-1, Locus XE1, Layer 2, depth 0.80 m, Field No. KLB-1, XE1/C/1962-63-5. NaOH pretreatment was also given. *Comment*: date is younger than expected archaeologically.
- 4090 ± 90**
2140 B.C.
- TF-241. Pre-Harappa culture**
Charcoal from Trench KLB-1, Locus XD1, Pit 4 sealed by Layer 2, depth 2.75 m, Field No. KLB-1, XD1, Qd.1/C/1963-64-2. NaOH pretreatment was also given.
- Karla series, Maharashtra**
- Karla (18° 45' N Lat, 73° 29' E Long), Dist. Poona, is site of famous Buddhist rock-excavations. Big trees have been used for rafters and ribs used in these "caves".
- 2075 ± 100**
125 B.C.
- TF-171. Buddhist rock excavations**
Wood from an inside rib fitted to "wall of rock cave." Few antholes were visible. NaOH pretreatment was also given. Sample subm. by K. A. Chowdhury.

TF-185. Buddhist rock excavations**2180 ± 95
230 B.C.**

Wood-rib from Karla Chaitya Cave No. 8. NaOH pretreatment was also given. Sample subm. by A. Ghosh.

Kausambi series, Uttar Pradesh

Kausambi (25° 20' N Lat, 81° 23' E Long), now known as Kosam, Dist. Allahabad, is located on N bank of Yamuna. It is known as capital of later Pandavas. Site is being excavated by G. R. Sharma, who subm. these samples.

TF-226. Rampart II**2110 ± 95
160 B.C.**

Charcoal from Trench KSB-GR, Locus YZ3, 1-2, Layer 12, depth 1.8 m, Field No. KSB/63/GR-138. *Comment:* excavator's archaeological date bracket for sample is ca. 535-185 B.C.

TF-225. N.B.P. ware deposits**2285 ± 105
335 B.C.**

Charcoal from Trench KSB-GR, Locus YZ3, 1-2, Layer 11, depth 1.6 m, Field No. KSB/63/GR-136.

TF-219. N.B.P. ware deposits**2325 ± 100
375 B.C.**

Charcoal from Trench KSB1-III-RD, Locus 2-7, Road I, depth 3 m, Field No. KSB/63/AP-9.

TF-221. N.B.P. ware deposits**2385 ± 100
435 B.C.**

Charcoal from Trench KSB-I-III-RD, Locus 5-7, Pit B sealed by Layer 12, depth 4.3 m, Field No. KSB/63/AP-15. *Comment:* excavator's date on archaeological considerations is ca. 400 B.C.

TF-252. Mahanadi Bridge, India, Mahanadi river-bed**5815 ± 140
3865 B.C.**

Drift wood from Mahanadi Bridge site (20° 25' N Lat, 85° 45' E Long), Well No. 8, depth 39 m, excavated during railway bridge construction work. Sample subm. by K. Ramesh Rao, Forest Res. Inst., Dehradun. NaOH pretreatment was also given.

TF-188. Morahana Pahar, India, rock-shelter**1530 ± 95
A.D. 420**

Charcoal from Morahana Pahar, Dist. Mirzapur, Trench MRA, Locus 1-2, Pit A sealed by 1, depth 0.09 m, Field No. MRA (M)-63/3002. NaOH pretreatment was also given. Sample subm. by G. R. Sharma. *Comment* (G.R.S.): as these shelters have been used by shepherds till modern times to light fires, later intrusions cannot be ruled out.

2005 ± 95**TF-169. Pataliputra, India, wooden palisades 55 B.C.**

Wood from Palisades of Kumrahar (25° 35' N Lat, 85° 18' E Long), Dist. Patna, from depth of 5.4 m. Ant-holes were visible in wood. NaOH pretreatment was also given. Sample subm. by K. A. Chowdhury. *Comment*: sample was "dated" to help botanical studies on decay of cell-walls.

Rajghat series, Uttar Pradesh

Rajghat (25° 18' N Lat, 83° 1' E Long), Dist. Varanasi, is well-known site on bank of River Ganga. Site was excavated by A. K. Narain, Banaras Hindu Univ., Varanasi, who subm. the samples.

2370 ± 105**TF-293. N.B.P. ware deposits 420 B.C.**

Charcoal from Trench RGT-XIA, Locus XI-XII, Layer 11, depth 9.45 m, Field No. RGT-XIA/1963-64-S. No. 2. *Comment*: sample belongs to early phase of N.B.P. ware.

2350 ± 95**TF-292. Black Slipped ware deposits 400 B.C.**

Charcoal from Trench RGT-Cutting B, Locus O-II', Layer 6, depth 5.9 m, Field No. RGT-Cut. B/1963-64-S.No. 5. Visible rootlets were handpicked. *Comment*: in the layer there is evidence of flood.

2190 + 85**TF-294. Black and Red ware deposits 240 B.C.**

Charcoal from Trench RGT-XIA, Locus X-XI, Layer 14, depth 11 m, Field No. RGT-XIA-1963-64-S. No. 4. *Comment*: sample derives from disturbed strata.

Rupar series, Punjab.

Rupar (30° 58' N Lat, 76° 32' E Long), Dist. Ambala, has given a sequence from the Harappan to late historical times. Site was excavated by Y. D. Sharma in 1953. Samples subm. by A. Ghosh.

2275 ± 100**TF-213. N.B.P. ware deposits 325 B.C.**

Charred wood from Trench RPR-1, Locus O-VIII, Layer 26, depth not given, Field No. RPR-1-1710.

2365 ± 100**TF-209. N.B.P. ware deposits 415 B.C.**

Charred wood from Trench RPR-2, Locus X'-XI', Layer 30, depth 11 m, Field No. RPR-2-3094.

1910 ± 90**TF-369. Saradkel, India, "Asura" culture A.D. 40**

Charcoal from Saradkel (23° 3' 30" N Lat, 85° 21' E Long), Dist. Ranchi, Trench SDK-2, Locus C3-C4, Layer 3, depth 0.01 m (?), Field

No. SDK-2/65-114. NaOH pretreatment was also given. Sample subm. by A. Ghosh. *Comment*: red ware sprinklers are associated with these deposits.

TF-371. Shomutepe, U.S.S.R., Eneolite period **2915 ± 95**
965 B.C.

Charcoal from Shomutepe (41° N Lat, 45° E Long), Dist. Kazakh (Azerbaijan), Lower stratum, depth 0.7 m. Sample subm. by I. Q. Nari-manov. *Comment* (I.Q.N.): sample derives from transitional phase between Eneolithic and Bronze-age periods.

TF-376. Sonpur, India, Pre-N.B.P. ware deposits **2510 ± 105**
560 B.C.

Charred rice from Sonpur, Dist. Gaya, Pit sealed by Layer 9, depth 4.55 m, Field No. SPR-XII. Sample subm. by B. P. Sinha.

Tekkalakota series, Mysore

Tekkalakota (15° 32' N Lat, 76° 53' E Long), Dist. Bellary, is an extensive neolithic site. Site was excavated by H. D. Sankalia, Deccan College, Poona, who subm. the samples. *Comment*: C¹⁴ dates show that Tekkalakota represents the middle phase and Utnur the early phase of Neolithic culture of S.

TF-277. Ash-pit **2220 ± 105**
270 B.C.

Charred grains from Trench A, Locus TKT-GWD, Layer 2, depth 0.3 m. NaOH pretreatment was also given. *Comment* (H.S.D.): sample derives from historical levels.

TF-262. Neolithic culture **3460 ± 135**
1510 B.C.

Charcoal from TKT-I, Trench 9, Layer 1, depth 0.25 m. NaOH pretreatment was also given. Visible rootlets were handpicked.

TF-239. Neolithic culture **3395 ± 105**
1445 B.C.

Charcoal from TKT-I, Trench 1, Pit 4 sealed by Layer 4, depth 1.3 m. NaOH pretreatment was also given.

TF-237. Neolithic culture **3465 ± 105**
1515 B.C.

Charcoal from TKT-I, Trench 1, Layer 4, depth 1 m. NaOH pretreatment was also given.

TF-266. Neolithic culture **3625 ± 100**
1675 B.C.

Charcoal from TKT-II, Trench 2, Layer 2, depth 0.17 m. Field No. 265. NaOH pretreatment was also given.

- 6085 ± 120**
4135 B.C.
- TF-372. Toyretepe, U.S.S.R., Eneolite period**
Charcoal from Toyretepe (41° N Lat, 45° E Long), Dist. Kazakh, stratum medium, depth 4 m. Sample subm. by I. Q. Narimanov.

II. GEOLOGIC SAMPLES

Warkala series, Kerala

Warkala (8° 44' N Lat, 76° 42' 20" E Long) coast has been subject of many geologic investigations. Charred wood dated here was part of Warkala formations of Kerala coast. Samples subm. by G. Prabhakar Rao.

- TF-201. Warkala formations** **>45,000**
Charred wood from Warkala formations, embedded ca. 0.3 m in compact clay.

- TF-202. Warkala formations** **>40,000**
Charred wood from Warkala formations, embedded ca. 0.3 m in compact clay. NaOH pretreatment was also given.
Comment: dating of these formations has a bearing on the possibility or otherwise of oil-bearing strata in the region and on causes of the present day coastal erosion. Samples also will date emergence of the Kerala coast.

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