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GIF NATURAL RADIOCARBON MEASUREMENTS III

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The dates detailed below are a selection of C^{14} dates obtained from February 1966 to December 1967 for geologic samples. The method is essentially the same as described previously in Radiocarbon, 1966, v. 8 p. 74-95. All samples were subjected to pretreatment, differing in individual cases, to remove contamination. On one of our three installations, modern transistorized equipment replaced the original electronics.

All dates reported have been calculated on the assumed half-life of 5568 yr for C^{14}, and of 1950 as the reference year.

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SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

A. France

Normandy sea shore series

Tangue is loose sediment consisting of silty sand, with clay and abundant remains of marine shells (total $Ca\ Co_3$: 40 to 48%), and fine organic particles (ca. 1% of total weight) commonly deposited on SW coasts of Normandy. Tangues dated here are, at present, overlain by sand dunes or forming outcrops on strand, at different alts. Coll. and subm. 1965 by P. Giresse, Fac. Sci., Caen, Calvados.

1470 ± 120
Gif-387. Heugueville, 885 **A.D. 480**

Tangue from bed 2 m thick, in estuary of Sienne R., at Heugueville (48° 53′ N Lat, 1° 40′ W Long), ca. 3 m above sea high tide level.

1250 ± 120
Gif-388. Pontorson **A.D. 700**

Very fine clayey tangue, 40 cm thick, under 2 m coarse tangue, which comes from alluvium of Couesnon R. in Bay of Mont Saint-Michel, near Pontorson (48° 34′ N Lat, 1° 30′ W Long). Top of coarse tangue is at high tide level.

1430 ± 120
Gif-389. Saint-Jean-Le Thomas **A.D. 520**

Tangue, 20 cm thick, underlain by 115 cm wind-blown sand, at Saint-Jean-Le Thomas (48 °44′ N Lat, 1° 31′ W Long), in Bay of Mont-Saint-Michel, ca. high tide level.

Gif-390. Hauteville, 2 **4250 ± 250**
2300 B.C.

Outcrop of shelly sand, 15 cm thick, discovered by erosion, on strand at Hauteville (48° 52′ N Lat, 1° 33′ W Long), under 20 cm tangue, 0.5 m under sea high tide level.

Gif-391. Hauteville, 1 **1680 ± 120**
A.D. 270

Clayey tangue just above Gif-390; at ca. sea high tide level. *General Comment*: most of the samples have been dated from fine organic particles of tangue (except Gif-390, dated from shells). J. Labeyrie suggests that Gif-387, ca. 3 m above other tangue deposits of series, could be eolian. On the contrary, Giresse *et al.* (1967) suggest that it is only known deposit of Dunkerkian transgression in Normandy.

Gif-367. Saint-Côme de Fresné, Calvados, Sc 16 **20,800 ± 1500**
18,850 B.C.

Peat from boring at Saint-Côme de Fresné (49° 20′ N Lat, 0° 37′ W Long), on coast of The Channel, Calvados; under 6.30 m yellow silt and 1 m gray clay, lying on calcareous bed rock; alt: mean sea level (± 0.5 m). Coll. and subm. 1965 by C. Larsonneur, Fac Sci., Caen, Calvados. *Comment*: pollen analysis indicates cold climate (*Pinus* minimum); belongs to Würm III (Delibrias and Larsonneur, 1966).

Gif-368. Ecalgrain, Manche, H 4 **12,600 ± 400**
10,650 B.C.

Outcrop of peaty clay from Baie d'Ecalgrain, in Hague (49° 44′ N Lat, 1° 54′ W Long), Manche, alt: + 5 m above mean sea level; covered by important consolidated solifluction flows which overlap surface. Coll. and subm. 1965 by C. Larsonneur. *Comment*: pollen stratigraphic position: *Pinus* maximum (Elhaï, 1962).

Gif-369. Vauville, Manche, H 8 **21,940 ± 1500**
19,990 B.C.

Outcrop of peaty clay on strand, covered in some places by sand bar, alt: mean sea level (± 0.5 m), Vauville (49° 38′ N Lat, 1° 50′ W Long), Manche. Coll. and subm. 1965 by C. Larsonneur. *Comment*: pollen analysis shows predominance of *Cyperaceae* and *Gramineae* indicating rather cold climate conditions.

Gif-370. Herquemoulin, Manche, H 7 **15,020 ± 400**
13,070 B.C.

Peat on sandy clay, on shore, alt: mean sea level (± 0.5 m) at Herquemoulin (49° 39′ N Lat, 1° 54′ W Long), Manche. Coll. and subm. 1965 by C. Larsonneur. *Comment*: absence of pollen; structure similar to Gif-368.

Asnelles series, Calvados

Peat beds separated by clayey levels, from Boring 1, Asnelles, Calvados (49° 20′ N Lat, 0° 34′ W Long). Alt at top of boring: + 0.35 m above mean sea level. Coll. and subm. by C. Larsonneur.

Gif-371. Asnelles, AS 2 **5680 ± 250**
3910 B.C.

Peat with some fresh water gastropods, from 20 cm below surface. Pollen stratigraphic position: *Quercus* and *Alnus* dominant. Coll. and subm. 1965.

Gif-728. Asnelles, AS 13 **8320 ± 200**
6370 B.C.

Peat from 115 cm below surface. Between this sample and Gif-371, 70 cm of gray clay. Coll. and subm. 1966. Pollen stratigraphic position: beginning of *Quercus*.

Gif-372. Asnelles, AS 3 **8710 ± 350**
6760 B.C.

Peat from 150 cm below surface. Pollen stratigraphic position: *Corylus* abundant. Coll. and subm. 1965.

Gif-729. Asnelles, AS 20 **10,100 ± 230**
8150 B.C.

Peat from 175 cm below surface. Coll. and subm. 1966. Pollen stratigraphic position: *Pinus* and *Betula* dominant.

General Comment: bog shows very coherent series of postglacial deposits. These 1st dates permit calculation of high rate of turbification ca. 8,000 B.P. and corroborate conclusions obtained from pollen analysis.

Gathemo series, Normandy

Peat samples from bog, at Gathemo, S of Vire (48° 58′ N Lat, 0° 53′ W Long), Normandy; alt 330 m. Dated to determine ages of phases of clearing in region. Coll. and subm. 1964 by H. Elhaï, Inst. Geog., Paris.

Gif-402. Gathemo 6 **500 ± 120**
A.D. 1450

Coll. 1965, 0.90 to 1 m under surface.

Gif-403. Gathemo 7 **2770 ± 150**
820 B.C.

Coll. 1965, 1.90 to 2 m depth.

Gif-137. Gathemo 8 **3680 ± 200**
1730 B.C.

Coll. 1961, 2.30 to 2.40 m depth.

General Comment: Gif-403 and Gif-137 agree with pollen analysis; Gif-137 is just above clearing level, giving palynological evidence of Atlantic period (Elhaï, 1960). Gif-402 seems too young.

Picardie series

Channel coast of Picardie is open and flat country with recent sedimentation between estuaries of Somme and La Conche Rivers. Hand borings in maritime marsh behind small sandy dunes revealed peaty levels separated by fluvial deposits and marine sand. These peats are now 4 km behind beach and dunes. Altitudes are related to mean sea level. Coll.

and subm. 1965, by J. Etienne and P. Robert, Co. d'Exploitation Pétrol. Chambourcy, Seine et Oise.

Gif-396. Merlimont, ML 1 bis, 19 m **7150 ± 300** **5200 B.C.**

(50° 24′ N Lat, 1° 35′ E Long). Bed of peat; alt − 9 m.

Gif-397. Merlimont, ML 1 bis, 8.50 m depth **3720 ± 200** **1770 B.C.**

Peaty clay, + 1 m.

Gif-398. Pont du Curé, PC 1, 8.40 m depth **6200 ± 300** **4350 B.C.**

(50° 24′ N Lat, 1° 36′ E Long). Peaty clay: alt − 3 m.

Gif-399. Pont du Curé, PC 1, 4.50 m depth **3750 ± 200** **1800 B.C.**

Peaty clay: alt + 1 m.

Gif-761. La Hollande LH 1, Picardie, 3 m depth **8430 ± 200** **6480 B.C.**

(50° 28′ N Lat, 1° 38′ E Long). Humus sand; alt + 2 m.

Gif-762. Berck-Plage, 25671 **560 ± 95** **A.D. 1390**

(50° 23′ N Lat, 1° 34′ E Long). Outcrop of sandy humus with clay, at foot of eroded dune, at high tide level.

Gif-763 bis. Fort-Mahon, FM 2 bis, 22 m depth **7980 ± 190** **6030 B.C.**

(50° 22′ N Lat, 1° 36′ E Long). Peat, 7 cm thick; alt − 17 m.

Gif-764. Fort-Mahon, FM 4, 21 m depth **9750 ± 200** **7800 B.C.**

Dusty peat; alt − 16 m.

General Comment (P.R.): very good concordance between C^{14} dates and pollen study along cores: these data added to sedimentologic study of region reflect history of formation of Picardie plain. Between 11,500 and 7500 B.P., sea had not yet reached Picardie plain, but local rise of mean river levels promoted spreading of fluvial estuary deposits; ca. 5000 B.P., sea covered region, and greatly eroded older deposits. Consistent with similar study on Holland littoral (Van Straaten, 1965).

Evian series, Haute Savoie

Some peaty levels have been found during borings to study water level at Evian (46° 24′ N Lat, 6° 35′ E Long), Haute Savoie. Evian, on Lake Geneva is at N of Vinzier plateau which is cut in SW part by Dranse Valley. Region was overspread by Rhône glacier during last glaciation. Although 214 m deep, deepest boring through plateau has only crossed Quaternary formations and not encountered bedrock. The 3 borings studied showed interstadial sediments of different facies and unequal thickness included in moraines. Upper moraine from 50 to 85 m thick. Coll. 1964 by B. Blavoux and subm. by L. Glangeaud, Lab. Geol. Dynamique, Sorbonne, Paris.

Gif-333. Boring Sionnex, S 1 (12); alt 728 m **23,500 ± 1200**
21,550 B.C.

Fragments of branches at 31.5 m depth, in black clay, 25 cm thick, at base of "interstadial" formation.

26,200 ± 1200
Gif-334. Boring Sionnex, S 1 (52) **24,250 B.C.**

Debris of branches and leaves at 104 m depth, in silt, 75 cm thick.

24,900 ± 1200
Gif-335. Boring Sionnex, S 1 (93) **22,950 B.C.**

Pieces of wood with debris of branches at 186.5 m depth, in silt and thin sand, 50 cm thick.

25,200 ± 1200
Gif-336. Boring Royal, S 2 (33); alt 467 m **23,250 B.C.**

Branches with many leaves, at 63.5 m depth, in thin sand, 20 cm thick.
General Comment: dates indicate that both moraine levels belong to Würm and that, more precisely, interstadial formations correspond to Würm III-IV. Pollen analyses show important variations of proportion of pines vs. herbs (Brun and Blavoux, 1966).

Gif-491. Armoy R. G. 25 B, Haute Savoie **⩾35,000**

Woody material in interstadial ligniferous level, in cliff; alt 480 m at Armoy, Dranse valley, Haute Savoie (46° 22′ N Lat, 6° 30′ E Long). From top, 15 m thick gravel, pebbles and sand, 35 m glacio-lacustrine moraine and 25 m interstadial lacustrine sand and clay including some ligneous remains at upper level. Coll. 1965 and subm. 1966 by A. Brun, Lab. Geol. Dynamique, Sorbonne, Paris.

Gif-739. Armoy R. G. D 58, Haute Savoie **⩾35,000**

Wood from same level as Gif-491. Coll. 1965 and subm. 1966 by A. Brun. *Comment for Gif-739 and Gif-491*: dates and stratigraphic considerations permit relation of Armoy Interstadial to Würm II-III. Good correlations with stratigraphic and pollen analysis results obtained for Evian series (Brun and Delibrias, 1967).

14,000 ± 300
Gif-774. Thonon-les-Bains, T 1, Haute-Savoie **12,050 B.C.**

Fragments of *Elephas primigenius* molar found in gravel pit, 1.5 km SE of Thonon-les-Bains (46° 20′ N Lat, 6° 28′ W Long). Subm. 1966 by A. Brun. *Comment*: tooth comes from late-Würm gravel deposits at top of glacial complex studied in Dranse valley (Armoy) and Vinzier plateau (borings at Evian). Collagen fraction extracted for dating.

Gif-386. La Balme, Savoie **2870 ± 200**
920 B.C.

Fragment of branch of giant oak tree; 2 m diam, 31 m long, 55 tons, in alluvium of Rhône bed, at La Balme (46° 02′ N Lat, 6° 58′ E Long), Savoie. Coll. 1883 and subm. 1965 by L. Lagier Bruno, Yenne, Savoie.

Gif-490. Lac Léman, L 66-395 **3910 ± 400**
1960 B.C.

Fragment of wood at 3.95 m depth in sediments of Lac Léman (Lake Geneva), off Lausanne (46° 23′ N Lat, 6° 29′ E Long). Coll. and subm. 1966 by C. Serruya, Centre de Recherches Géodynamiques, Thonon-les-Bains. *Comment*: date indicates speed of sedimentation of 1 m per 1000 yr which seems correct for lacustrine environment (Serruya and Sauvage, 1966). Sample mixed with dead gas for counting.

Ballon d'Alsace series, Vosges

Peat from 2 peat bogs of Ballon d'Alsace (47° 49′ N Lat, 6° 52′ E Long). Coll. 1965 and subm. by H. Elhaï.

Gif-404. Ballon d'Alsace, Fagne de la Savoureuse **3650 ± 200**
1700 B.C.

0.90 cm to 1 m depth.

Gif-405. Ballon d'Alsace, Fagne de la Savoureuse **3800 ± 200**
1850 B.C.

2.40 m to 2.50 m depth.

Gif-406. Ballon d'Alsace, Grande Goutte **4780 ± 250**
2830 B.C.

4.80 m to 4.90 m depth.

General Comment: in good agreement with pollen analysis. *N.B.* rapid peat formation ca. 3700 B.P.

Andlau marsh series, Bas Rhin

Peat from basal level of peat bog formed in alluvial deposit of Andlau marsh. Coll. 1964 and subm. 1965 by M. Schaeffer, Fac. Sci. Orsay.

Gif-500. Innenheim, A 13-A/GO-14 **5920 ± 150**
3970 B.C.

(48° 29′ N Lat, 7° 35′ E Long)

Gif-501. Meistrazheim, M (45) a **5130 ± 150**
3180 B.C.

(48° 27′ N Lat, 7° 32′ E Long)

Volcanism series, Massif Central

Gif-486. Puy du Montchier **8540 ± 300**
6590 B.C.

Plant debris found at 1 m depth on hillside of Puy under layer of volcanic cinders, Puy de Montchier (45° 45′ N Lat, 3° 08′ E Long) Puy

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de Dôme. "Puy" or "Dome" are special designations for volcanoes on E side of Massif Central. Coll. and subm. 1965 by R. Brousse, Fac. Sci. Orsay. *Comment*: dates volcanic eruption which carbonized plants; emission of volcanic cinders being mostly domitic, formation of dome can be dated (Brousse *et al.*, 1966).

Gif-721. Col de la Moreno, Massif Central **8730 ± 300** **6780 B.C.**

Carbonized oak found under 2.80 m ashes (trachytic), Col de la Moreno (45° 44′ N Lat, 2° 56′ E Long), Puy de Dôme. Coll. 1966 and subm. A. Rudel, Ecole Normale, Clermont-Ferrand.

General Comment: age and date of Gif-486 are comparable to date of Sa-94: 8580 ± 350 B.P. (Radiocarbon, 1964, v. 6, p. 239): these 3 samples date with certainty one of last great eruptions of "Chaine des Puys" in Massif Central. Most of lavas, lapilli, or cinders emitted by these volcanoes, either acidic or basic were emitted ca. 8500 yr ago.

Passe-Castillonnaise series, Gironde

Marine shell samples from "Passe-Castillonnaise," in Gironde estuary. "Passe-Castillonnaise" is ancient littoral band of shelly sand, separating existing alluvial plain of Mattes from Bas-Médoc. Coll .and subm. 1966 by P. Dutil, Stat. Agron. de Chalons-sur-Marne.

Gif-542. "La Fosse," Saint-Vivien de Médoc **1870 ± 150** **A.D. 80**

(45° 26′ N Lat, 1° W Long), 50 to 65 cm depth.

Gif-543. "Les Cabireaux," Talais **2160 ± 150** **210 B.C.**

(45° 29′ N Lat, 1° 04′ W Long), 40 to 50 cm depth.

General Comment: date step in formation of estuary of Gironde R., and show that present shape of S side of estuary is almost unchanged since that time.

Gif-347. Saint-Léger en Yvelines **5680 ± 300** **3730 B.C.**

Phragmites peat, 60 cm depth, from filled ancient pond, at Saint-Léger en Yvelines (48° 38′ N Lat, 1° 50′ E Long), in Rambouillet forêt, 30 km S of Paris. Coll. 1964 and subm. by G. Jalut through M. Van Campo, Mus. d'Hist. Nat., Paris. *Comment* (G.J.): agrees well with pollen analysis which dated this level from transition between Atlantic and Sub-Boreal periods. Places more precisely in middle Atlantic period 1st deforestations observed in pollen diagram.

Gif-348. Belle-Ile-en-Mer **2680 ± 200** **730 B.C.**

Peat, 80 cm depth, in submerged boring, 5 m under high tides at "Ster-Vras" in Belle-Ile (47° 20′ N Lat, 3° 10′ W Long). Coll. by N. Planchais and subm. by M. Van Campo. *Comment* (N.P.): pollen analysis revealed presence of Sub-Atlantic moor succeeding to poorly forested vegetation, probably related to end of Sub-Boreal period. Confirms local

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recent subsidence already observed in Saint-Jacques gulf of S coast of Bretagne (Sa-190, Radiocarbon, 1964, v. 6, p. 235, 2350 ± 150, 4 m under high sea level).

24,400 ± 1500
Gif-750. Camaret, Finistère **22,450 B.C.**

Peaty level between 2 solifluction flows at Camaret, Finistère (48° 16′ N Lat, 4° 37′ W Long). Coll. and subm. 1966 by M. T. Morzadec, Fac. Sci., Rennes. *Comment*: according to pollen analysis (*Alnus* dominant, *Abies* on top) peat horizon originates from interglacial period; date confirms it is Paudorf interstadial.

B. Africa

11,580 ± 400
Gif-320. Bassin of La Tafaina, Madagascar **9630 B.C.**

Humus 30 cm below soil covering, from upper terrace, in Basin of La Tafaina (19° 09′ S Lat, 47° 29′ E Long), Madagascar. This upper terrace is constituted by first generation of "Lavaka"; lavaka is a Madagascan name to design large circular excavations in lateritic clay, a result of process of gully erosion (Petit and Bourgeat, 1966). Coll. and subm. 1964 by J. Riquier, Office de Recherche Sci. et Techn. Outre Mer, Brazzaville, Congo. *Comment*: dates transition between alluvial and erosion phases. Corresponds to drier time between Gamblian and Makalian in Africa.

Delta of Senegal series

Marine shells (*Arca senilis*) from SW of Senegal's delta. Shelly layers were found in deltaic terraces, between sandy deposits. Coll. and subm. 1964 by P. Michel, Dept. Geog., Fann, Dakar, Sénégal.

5050 ± 250
Gif-362. Delta du Sénégal, 911 a **3110 B.C.**

Shelly horizon 1.5 m thick, in littoral strandline (15° 56′ N Lat, 16° 27′ W Long); alt + 2.70 m. *Comment* (P.M.): by alt and facies, deposit appears as kitchen midden on ancient offshore bar in gulf of Nouakchott.

1790 ± 120
Gif-364. Delta du Sénégal, 921 **A.D. 160**

(15° 54′ N Lat, 16° 28′ W Long). Shells from loc. as Gif-362; alt + 2 m. *Comment*: same as for Gif-362.

1620 ± 130
Gif-363. Delta du Sénégal, 918 **A.D. 330**

Shelly level, 70 cm thick, from low terrace (15° 54′ N Lat, 16° 29′ W Long), in lagoon, alt + 1.5 m. *Comment*: dates natural deposit in lagoon between 2 offshore bars, W. Diarher.

Trou au Natron series, Tibesti, Tchad

"Trou au Natron" (20° 58′ N Lat, 16° 33′ E Long) at ca. 2,200 m alt in Tibesti, SE Sahara. This huge caldera (depth: 650 m, surface: 40 sq. km) formed by subsidence following emission of big ignimbrite masses (H.T.), was formerly filled by a lake, recorded by lacustrine sediments. Samples coll. 1965 by H. Tazieff, Mission Volcanol. du Tibesti and subm. by H. Faure, Fac. Sci. de Dakar, Sénégal.

12,400 ± 400
Gif-378. Trou au Natron, 4537 **10,450 B.C.**

Calcareous crusts on lava blocks of SW wall, 500 m under edge of caldera; alt 1775 m.

14,790 ± 400
Gif-379. Trou au Natron, 4545 **12,840 B.C.**

Tiny gastropods in calcareous diatomite ca. 30 m above floor of crater; alt 1580 m.

14,970 ± 400
Gif-380. Trou au Natron, 4546 **13,020 B.C.**

Gastropods in calcareous diatomite from upper terrace, 425 m to 400 m under SW edge of caldera; alt 1850 m, 1 m from top of diatomite zone. *General Comment*: diatomites from upper terrace and bottom are of same period, 14,790 and 14,970 B.P.; they are deposits of same lake more than 350 m deep. Age of calcareous crust (12,400 B.P.) appears satisfactory: this calcareous deposit should have begun 2500 yr later, when concentration in water was higher because of evaporation. Dates agree with age of lacustrine period in Nigeria (T 338, Radiocarbon, 1964, v. 6, p. 286; Faure *et al.*, 1963).

C. Miscellaneous

8230 ± 350
Gif-321. Irazu volcano, Costa Rica **6280 B.C.**

Charcoal found at foot of Irazu volcano under large andesitic volcanic flow, Rio Reventazon, Costa Rica (10° N Lat, 85° W Long). Coll. 1964 by Jorge Umana and subm. by H. Tazieff, 15 quai Bourbon, Paris. *Comment*: recent eruptions discharged only fine ash and bombs. Confirms eruption dated by W-1548: 13,800 ± 300 B.P. (Radiocarbon, 1967, v. 9, p. 526) is not last flow of Irazu volcano.

Lac Saint-Jean Area series, Quebec

Fossil shells from lac Saint-Jean Area, Quebec, coll. 1965 and subm. 1966 by P. Lasalle, Dept. Nat. Res., Quebec.

9560 ± 350
Gif-423. Desbiens, Quebec, Canada **7610 B.C.**

Shells (*Macoma baltica*) from pit opened in deltaic sand at mouth of Metabetchouan R., S of Lake Saint-Jean, Quebec (48° 24′ 42″ N Lat, 71° 58′ 24″ W Long); alt 119 m.

10,060 ± 350
Gif-400. Metabetchouan, Quebec, Canada **8110 B.C.**

Shells (*Macoma baltica, Portlandia arctica,* and *Hiatella arctica*) from reworked outwash in gravel pit (48° 25′ 30″ N Lat, 71° 50′ W Long); alt 153 m.

Gif-424. Metabetchouan, Quebec, Canada **10,250 ± 350**
8300 B.C.

Shells (*Macoma baltica*) from shallow cut in sandy reworked outwash (48° 26′ N Lat, 71° 51′ W Long), alt 113 m.

Gif-401. Saint-Bruno, Prov. Quebec, Canada **11,000 ± 350**
9050 B.C.

Shells (*Hiatella arctica*) from shallow water sediments (probably reworked outwash or reworked till) of Champlain Sea (45° 33′ 25″ N Lat, 73° 19′ 20″ W Long); alt ca. 135 m.

General Comment (P.L.): Gif-424 is oldest date obtained on marine shells from Lake Saint-Jean dist.; is minimum for deglaciation. Date is minimum also for position of ice front at present location of assumed Saint-Narcisse moraine extension S of Lake Saint-Jean. Gif-400 and Gif-423 date same episode of marine invasion in Lake Saint-Jean dist. Gif-401 agrees with other dates obtained from fossil marine shells of Champlain Sea (Lasalle and Rondot, 1967).

Gif-377. Island of Bali, Indonesia **22,000 ± 1500**
20,050 B.C.

Carbonized wood under ignimbrite from caldera of Batur, 10 km diam, near village of Marga (8° 27′ S Lat, 115° 11′ E Long), Is. of Bali, Indonesia. Coll. by G. Marinelli and subm. 1965 by H. Tazieff. *Comment*: dates formation of caldera.

Gif-373. Phnom-Penh, Cambodia **5920 ± 300**
3970 B.C.

Peaty layer, 14 to 14.4 m, alt − 4 m, in boring of Bassac, Phnom-Penh (11° 35′ N Lat, 104° 55′ E Long), Cambodia. Coll. by Soc. Française des Dragages and subm. 1965 by J. P. Carbonnel, Fac Sci. Paris. *Comment*: dates cambering of this region which separates Great Lake of Cambodia from Mekong delta. Compare Sa-237, 5720 B.P. (Radiocarbon, 1965, v. 7, p. 243) which dated beginning of present sedimentation in Great Cambodia Lake; present structure is supposed to result chiefly from tectonic movement.

Spitsbergen series

Gif-385. Spitsbergen 1 **9560 ± 350**
7610 B.C.

Whale bone from upraised beach at + 6 m alt, Kwadelanke point, Baie du Roi, Spitsbergen (79° 40′ N Lat, 11° 40′ E Long). Coll. and subm. 1965 by P. Gabert, Fac. Lettres d'Aix-en-Provence, Bouches du Rhône.

Gif-894. Sarsöya, Spitsbergen **9600 ± 220**
7650 B.C.

Shells of bivalves, taken *in situ* from marine silty sand, 1.50 m above high tide, at Sarsöya, Spitsbergen (78° 48′ N Lat, 12° 12′ W Long). Coll. and subm. by A. Guilcher, Inst. Geog., Paris.

General Comment: ages identical with those found for terraces at + 11 m, Gif-317: 9260 ± 350, + 13 m, Gif-318: 9350 ± 350, + 20 m, Gif-319: 9650 ± 50 (Radiocarbon, 1966, v. 8, p. 91); confirm rapid isostatic uplift ca. 9000 B.P. of this part of Spitsbergen coast.

II. CORAL FROM PACIFIC ATOLLS

During experimental drilling in 1964 by French A.E.C. in Mururoa atoll, Tuamotu Is., continuous cores of coral were extracted. C^{14} measurements were done on upper part of 2 cores: "Colette" core, which reached basalt at 438 m, and "Anémone" only 20 m deep. Deep samples were dated by Th/U. Dated samples are related to mean sea level, at ± 0.2 m for "Colette" core and $^{+0}_{-1}$ m for "Anémone." Subm. 1965 by J. Labeyrie.

Gif-621. Living coral **+3%**

(17° 40′ S Lat, 149° 30′ W Long). Living coral, at −2 m along seaward side of N reef of Tahiti. Subm. 1965 by J. Labeyrie. *Comment*: carbon activity of sea water in region is not measured; may be compared to Oceanic measurements of sea water off California in 1965: + 8 to + 12% (Radiocarbon, 1966, v. 8, p. 467-497).

Colette series

Coral core, N part of ring of Mururoa atoll (21° 47′ S Lat, 138° 54′ W Long); alt + 0.8 m.

Gif-634.	**"Colette", surface, + 0.80 m, massive coral**	**3020 ± 200** **1070 B.C.**
Gif-622.	**"Colette", −1 m, sand and fragments of coral**	**5300 ± 300** **3350 B.C.**
Gif-624.	**"Colette", −3 m, sand and fragments of coral**	**5880 ± 300** **3930 B.C.**
Gif-625.	**"Colette", −5.4 m, sand and fragments of coral**	**4990 ± 300** **3040 B.C.**
Gif-636.	**"Colette", −6.1 m, massive coral**	**5420 ± 300** **3740 B.C.**
Gif-626.	**"Colette", −7 m, massive coral**	**⩾25,000**
Gif-627.	**"Colette", −9 m, sand and fragments of coral**	**⩾30,000**
Gif-628.	**"Colette", −20 m, sand and fragments of coral**	**⩾30,000**

Anemone series

Coral core, E part of ring of Mururoa atoll (21° 51′ S Lat, 138° 47 W Long); alt + 3 m.

Gif-629.	**"Anemone", surface, + 3 m, massive coral**	**3610 ± 200** **1160 B.C.**
Gif-630.	**"Anemone", sea level, sand and coral fragments**	**2910 ± 200** **960 B.C.**
Gif-631.	**"Anemone", −1 m, conglomerate (sand and coral fragments)**	**5550 ± 300** **3600 B.C.**
Gif-632.	**"Anemone", −3 m, massive coral**	**5600 ± 300** **3650 B.C.**
Gif-633.	**"Anemone", −5 m, massive coral**	**8200 ± 350** **6250 B.C.**
Gif-637.	**"Anemone", −7 m, conglomerate and sand**	**17,300 ± 800** **15,350 B.C.**
Gif-638.	**"Anemone", −9 m, massive coral**	**⩾30,000**

General Comment: very similar results obtained by Thurber *et al.* (1965), for Eniwetok atoll (12° N, 162° E), 8,500 km off Mururoa; suggests that level fluctuations observed are due not to local crustal movements but to eustatic phenomena. At Mururoa, local subsidence rate is negligible: 6 cm per 1000 yr as mean value averaged over 7×10^6 yr. Several important steps in eustatic sea levels may be deduced:

1) at ca. −7 m appears an old surface of atoll, pre-Würm (dated at 120,000 to 160,000 yr by Th^{230}-U^{234}, Labeyrie *et al.*, 1968). At that time, surface was a few m. above, or at present sea level.
2) this level became submerged at ca. 8000 B.P.
3) very rapid rise of sea level occurred at ca. 5500 B.P., from ca. −6 m to −1 m.
4) rapid rise seems to have occurred at ca. 3000 to 3600 B.P. bringing sea level to +3 m.
5) rough following recent history of atolls may be suggested: majority of Pacific and Indian Ocean atolls emerged during Würm's cold period, submerged from 8000 to 5000 B.P., then emerged for short time, then submerged again until 3500 B.P., and emerged again.

Alt. over present sea level of all atolls must be 3 m at uppermost.

III. CAVE CALCAREOUS FORMATIONS

Formation of cave deposits in limestone is due to well known mechanism: seepage waters dissolve biogenic CO^2 in biologically active layers of soil and are able to dissolve some Ca CO^3 from limestone. If this water containing Ca, CO^2, CO^3 H^-, and CO^{3--} ions in equilibrium emerges into cave, most CO^2 escapes from water and Ca CO^3 precipitates as stalactites, stalagmites, or other calcareous structures. Only part of carbon of these deposits is of biogenic origin; our preliminary experiments in laboratory show that 1 out of 3 carbon atoms comes from limestone, and therefore activity of recent calcareous deposits should be depleted by ca.

34% of recent biogenic carbon activity. This proportion seems fairly independent of temperature variations, as long as acid carbonic solution is saturated with calcium carbonate. This has been confirmed by measuring C^{14} activity of 2 recent stalagmites, grown in 2 caves differing widely in climatic conditions; the 1st from Orgnac, relatively hot (12.6°C) dry country; the 2nd from Grange-Mathieu, cooler (10°C) and very humid country, Jura, France. Chemical measurements on 40 l. of cave water dropping on big stalagmite in Orgnac, gave 33mg/l of limestone carbon and 63 mg/l of biogenic carbon.

A. Direct determination of biogenic carbon proportion

Results are given in δ% vs 0.95 NBS oxalic acid.

Stalagmite D series, Orgnac, Ardèche, upper part

In 1st Room A of "New Orgnac" cave, communicating with Aven d'Orgnac cave (44° 18′ N Lat, 4° 26′ E Long); alt 200 m; thickness of limestone above room: ca. 70 m. Big white stalagmite in pure calcite, 2.20 m long, 85 mm diam, taken *in situ*. Coll. 1966 by J. C. Duplessy and G. Delibrias, C. F. R., C. N. R. S., Gif-sur-Yvette.

Gif-616. Head, S 8 **−35.5%**

Superficial level, ca. 1 mm thick, filed off. $\delta C^{13} = -10.41‰$

Gif-618. Head, S 10 **−35%**

Second superficial level, ca. 1 mm thick, filed off. $\delta C^{13} = -10.61‰$

General Comment: these 2 dates indicate within 2% same proportion as lab experiments, Stalagmite was almost dry, which explains why nuclear explosion C^{14} increase is not apparent.

Gif-609. Air of Room A, January 1966 **+11%**

CO^2 coll. by slow bubbling through solution of Ba (OH)2. *Comment*: during end of 1965, oak leaves from ground above cave are much more enriched in C^{14}: 83%. Air of Room A is in slow exchange with free atmosphere; residence time is at least several yr.

Gif-608. Water of stalactite of same Room A **−4%**

CO^2 and bicarbonates dissolved in 40 l. water dropping along stalactite, with large surface of exchange with ambiant air. *Comment*: residence time of water in upper limestone layers of this room is at least several yr.

Gif-617. Small formations, S 9, Orgnac **+15%**

Small and fine stalactites 1 and 2 cm long formed from Nov. 1965 to Jan. 1966, at entrance of Aven d'Orgnac cave. *Comment*: in this part, air is exchanged quickly and residence time of dropping water is probably short. From this and from C^{14} enrichment of tree leaves in same region (+83% for 1965), biogenic carbon content is 63%.

Stalagmite B, Grange-Mathieu series, Jura, upper part

Cave of Grange Mathieu (47° 09′ N Lat, 5° 59′ E Long); alt 300 m; thickness of limestone above room: ca. 15 m. Large white calcite stalagmite, 5.50 m long, 130 mm diam at bottom, 95 mm at top, W of entrance pit in Room C. Sawed out at base. Coll. 1967 by J. C. Duplessy, D. Nordemann, and J. Labeyrie, C. F. R., C. N. R. S., Gif-sur-Yvette.

Gif-652. A B I, head **+18.5%**

Superficial layer, 1 mm thick, filed off. $\delta C^{13} = -7.20‰$

Gif-660. A B I, head **+21%**

2nd layer, 1 mm thick, filed off. $\delta C^{13} = -7.75‰$

Gif-661. A B I (1), 3 cm from top **+7%**

$\delta C^{13} = -7.36‰$

Gif-664. A B I (2), 8 cm from top **+3.5%**

Gif-666. A B I (11), 54 cm from top **−36.5%**

$\delta C^{13} = -8.08‰$

Gif-653. A B I (12), 64 cm from top **−34.5%**

$\delta C^{13} = -8.69‰$

Gif-667. A B II (1), 70 cm from top **−36%**

$\delta C^{13} = -8.66‰$

General Comment: for at least 25 yr this stalagmite has been in well-aerated room with relatively large (cross section 2 m^2, length 30 m) horizontal connection with bottom of entrance pit (depth 25 m, cross section 200 m^2). Same proportion of biogenic carbon vs. limestone carbon as in Orgnac is found in upper part of this stalagmite, except for top, obviously enriched with bomb C^{14}. See below apparent ages of remnant sections of this stalagmite.

Gif-663. Elder leaves, Grange Mathieu **+76%**

Remains of elder leaves grown in 1966. Coll. March 1967, to determine C^{14} enrichment in plants, just above cave.

B. Dating of levels in cave stalagmites

From above measurements, proportion of biogenic carbon in pure calcite stalagmite is considered 65% throughout their formation, for both caves of Orgnac and Grange-Mathieu.

Stalagmite D series, Orgnac

1320 ± 250

Gif-614. V, S 6 **A.D. 630**

270 mm from head, sampling in center of stalagmite. $\delta C^{13} = -10.77‰$

1200 ± 250

Gif-615. V S 7 **A.D. 750**

270 mm from head, sampling from external part of stalagmite. *Comment*: cylindrical stalagmite, probably formed of successive horizontal layers. If compared to Gif-614, difference in dates is not statistically signifi-

cant and results do not imply difference between age of external part and center of stalagmite.

Gif-619. II, S 12 — **2850 ± 300**, **900 B.C.**

660 mm from head.

Gif-643. III-4, S 19 — **4160 ± 350**, **2210 B.C.**

880 mm from head. $\delta C^{13} = -10.96‰$

Gif-611. III, S 3 — **4400 ± 350**, **2450 B.C.**

1.16 mm from head. $\delta C^{13} = -10.03‰$

Gif-612. II, S 4 — **5650 ± 400**, **3700 B.C.**

$\delta C^{13} = -9.93‰$

Gif-613. I, S 5 — **6480 ± 400**, **4530 B.C.**

2.06 m from head, at base of stalagmite. $\delta C^{13} = -9.22‰$

General Comment: dates permit calculation of mean growth rate of 32 mm/100 yr. However, this rates varies all along stalagmite and seems to have been more rapid ca. 4000 B.P.: ca. 90 mm in 100 yr; at present it seems very slow (< 20 mm in 100 yr): this stalagmite is almost "dead" (J. Labeyrie *et al.*, 1967).

Stalagmite C series, Orgnac

In same room as Stalagmite D; "living" white stalagmite of pure calcite, 370 mm long ,60 mm diam., sawed in place.

Gif-640. Head, 1st surface layer, S 15 — **−14%**

Ca. 1 mm thick.

Gif-641. Head, 2nd layer, S 16 — **−10%**

Ca. 1 mm thick.

Gif-642. Head, 3rd layer, S 18 — **−15%**

Ca. 1 mm thick.

Gif-610. Base, S 1 — **6800 ± 230**, **4850 B.C.**

General Comment: it is not clear whether superficial layers are contaminated by bomb C^{14}. More measurements are necessary.

Reddish stalagmites series, Orgnac

Sampling on red stalagmite, found broken and lying on ground.

Gif-639. Reddish Stalagmite 1, S 14 — **−89%**

Head, superficial layer.

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Gif-620. Reddish Stalagmite 1, S 13 **≥30,000**
Bottom.

Gif-651. Reddish Stalagmite 2, S 17 **≥30,000**
Head, superficial layer.

Gif-690. Reddish Stalagmite 3 **−92%**
Bottom.

General Comment: reddish stalagmites are very old, and made of thin layers of calcite intercalated with colloidal red clay, probably present in dropping water.

Stalagmite B series, Grange-Mathieu

Gif-668. A B II (2), 76.5 cm from top **510 ± 140**
A.D. 1440
$\delta C^{13} = -9.93‰$

Gif-669. A B II (3), 83 cm from top **700 ± 140**
A.D. 1250
$\delta C^{13} = -8.75‰$

Gif-672. A B II (6), 91 cm from top **500 ± 140**
A.D. 1540
$\delta C^{13} = -7.68‰$

Gif-673. A B II (8), 96 cm from top **310 ± 140**
A.D. 1640
$\delta C^{13} = -8.85‰$

Gif-674. A B II (10), 1.02 m from top **800 ± 140**
A.D. 1150
$\delta C^{13} = -6.96‰$

Gif-675. A B II (12), 1.07 m from top **860 ± 140**
A.D. 1090
$\delta C^{13} = -7.00‰$

Gif-676. A B II (14), 1.12 m from top **630 ± 140**
A.D. 1320
$\delta C^{13} = -6.25‰$

Gif-654. A B II (15), 1.15 m from top **880 ± 140**
A.D. 1070
$\delta C^{13} = -9.86‰$

Gif-678. C (2), 1.26 m from top **850 ± 140**
A.D. 1100
$\delta C^{13} = -8.35‰$

Gif-679. C (4), 1.36 m from top **1020 ± 140**
A.D. 930
$\delta C^{13} = -7.49‰$

Gif-680. C (6), 1.48 m from top — **1130 ± 140**
A.D. 820
$\delta C^{13} = -9.57‰$

Gif-681. C (10), 1.70 m from top — **2030 ± 140**
80 B.C.
$\delta C^{13} = -7.45‰$

Gif-656. C (13), 1.87 m from top — **2000 ± 140**
50 B.C.
$\delta C^{13} = -9.00‰$

Gif-682. D (2), 1.97 m from top — **2080 ± 150**
130 B.C.
$\delta C^{13} = -7.58‰$

Gif-683. D (5), 2.11 m from top — **2390 ± 150**
440 B.C.
$\delta C^{13} = -6.40‰$

Gif-684. D (7), 2.21 m from top — **2480 ± 150**
530 B.C.
$\delta C^{13} = -6.50‰$

Gif-657. D (9), 2.31 m from top — **2630 ± 150**
680 B.C.
$\delta C^{13} = -8.67‰$

Gif-677. E F 11, 2.97 m from top — **3890 ± 170**
1940 B.C.
$\delta C^{13} = -8.80‰$

Gif-659. E F IV, 3.63 m from top — **5250 ± 200**
3300 B.C.

Gif-687. G 1 (2), 3.97 m from top — **6300 ± 230**
4350 B.C.
$\delta C^{13} = -7.77‰$

Gif-658. G I (4), 4.31 m from top — **5730 ± 230**
3780 B.C.
$\delta C^{13} = -8.34‰$

Gif-688. G II (a), 4.62 m from top — **6980 ± 230**
5030 B.C.
$\delta C^{13} = -7.84‰$

Gif-655. G II (b), 5.00 m from top — **7980 ± 170**
6030 B.C.
$\delta C^{13} = -8.23‰$

General Comment: same stalagmite as above (Stalagmite B). Artificial C^{14} still present at least 8 cm from top. From now to ca. 100 B.P., extremely rapid growth (70 cm/100 yr), supposedly due to sudden enlarge-

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ment of entrance of Room C by rockfall, creating a draught and rapid evaporation of water (relative humidity in Room C has same variations as in entrance peat, instead of being steadily ca. 100% as in Orgnac A and other rooms of Grange-Mathieu). Important perturbations between 76 cm and 1.15 m (very roughly ca. 700 B.P.) not yet explained. High speed between 800 B.P. and 1150 B.P., and between 2000 B.P. and 2200 B.P., low between 1200 B.P. and 2000 B.P. (2.5 cm/100 yr), roughly steady rate between 2200 B.P. and 8000 B.P. (5.3 cm/100 yr).

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