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DEPARTMENT OF EARTH SCIENCES AT THE UNIVERSITY OF ROME RADIOCARBON DATES II

GILBERTO CALDERONI

Department of Earth Sciences, University of Rome "La Sapienza", Piazzale Aldo Moro 5
I-00185 Rome, Italy

INTRODUCTION

This paper includes ^{14}C measurements of geological and environmental samples processed by liquid scintillation counting of benzene between 1991 and the end of 1992. All samples, from central and northern Italy and from the Gulf of Venice, Adriatic Sea, relate to scientific projects conducted in collaboration with colleagues from both Italian universities and National Council of Research (CNR) institutions.

Except as otherwise indicated, charcoal, peat and wood samples are routinely pretreated with dilute HCl, NaOH and HCl at boiling temperature prior to combustion. Paleosols and marine sediments are measured by using either the NaOH-extractable humic acids or the whole humic matter (Alessio *et al.* 1989).

Both NBS Oxalic Acid I and ANU Sucrose were used as modern carbon standards; background benzene is currently synthesized from a homogeneous batch of ^{14}C-free coke used in Rome since Ballario *et al.* (1955) established the first ^{14}C lab. Dates are expressed in conventional ^{14}C yr (BP) relative to AD 1950 and based on the 5568-yr half-life of ^{14}C. Results for geochemical samples, based on the ^{14}C half-life of 5730 yr, are reported in terms of $\Delta^{14}C$ (Stuiver and Polach 1977). Reported errors ($\pm 1\sigma$) account only for uncertainties in activity measurements of sample, background and modern standard. Results with quoted $\delta^{13}C$ values (w.r.t. PDB) were corrected for fractionation.

Procedures for benzene synthesis and lab equipment were as reported earlier (Calderoni and Petrone 1992). ^{14}C activities were measured in 1-, 2- and 3-g geometries with a Packard Tri-Carb® 2260XL beta-spectrometer; efficiency averaged 69% for a counting window with the lower energy discriminator set close to the tritium endpoint. Each sample batch included at least 2 modern vials and 1 background vial.

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Massa Fiscaglia Series

An almost continuous core *ca.* 50 m long was taken in 1988 at Massa Fiscaglia, Ferrara, Lombardia region, northern Italy (45°49′45″N, 12°52′55″E) to assess lithology and paleoenvironmental significance of the alluvial sediment cover. The study area, located on the alluvial Pianura Padana, experienced a huge Flandrian marine transgression, which proceeded westward from the ancient Adriatic Sea following the end of the last glaciation. Core samples submitted July 1992 by M. Bondesan, Department of Geologic and Paleontologic Sciences, University of Ferrara.

Rome-244. Massa Fiscaglia S#1 **1990 ± 70** $\delta^{13}C = -27.0‰$

Gray-brown clayey peaty silt, 2.20–2.30 m deep, including well-preserved fragments of plant remains.

Rome-245. Massa Fiscaglia S#2 **3540 ± 75** $\delta^{13}C = -27.2‰$

Peaty level interbedded in gray clayey silt layers from 5.65-5.75 m depth.

Rome-246. Massa Fiscaglia S#3 **3880 ± 80** $\delta^{13}C = -26.9‰$

Peaty level, 6.20–6.30 m deep, overlying a 1.70-m-thick gray clay layer containing gastropod shells.

Rome-247. Massa Fiscaglia S#4 **5070 ± 80** $\delta^{13}C = -27.3‰$

Gray clay level rich in plant remains, 7.85–7.95 m deep.

Rome-248. Massa Fiscaglia S#5 **5680 ± 90** $\delta^{13}C = -26.7‰$

Thin peaty clayey silt level, 8.83–8.85 m deep, overlying two distinct, thicker clayey peaty layers.

Rome-249. Massa Fiscaglia S#6 **6200 ± 90** $\delta^{13}C = -27.5‰$

Peat level, 12.20–12.50 m deep, interbedded in two clayey silt layers.

Rome-250. Massa Fiscaglia S#7 **>43,000** $\delta^{13}C = -28.5‰$

Small fragments of carbonaceous material scattered in a silty layer from 48.55–48.60 m depth underlying a 27-m-thick sandy layer.

Comment: Bulk organic matter was dated following exhaustive treatment with 18% HCl to remove carbonates. Samples date the recurrence of marshy conditions from the middle through late Holocene. The few dates available for this geological scenario are from peaty core samples from the lagoon of Venice (Bonatti 1968) and offshore the lagoon (Lenaz and Taviani 1986), *ca.* 80 km east of the study area, encompassing the interval, 12,210–23,450 BP. However, the lack of marine sediments in the core precluded dating the Flandrian transgression over this area.

Lago Lungo Series

Lago Lungo is an ephemeral small pond, *ca.* 7 km north of Rieti, Latium, central Italy (24°28′12″N, 12°40′17″E). During late Quaternary times, it was an active sedimentation basin for alluvium in its wide catchment area. In 1989, the sediment was drilled to 81.50 m depth, to study climatic change through pollen analysis and to establish a time scale for the Pleistocene-Holocene transition. Core samples collected and submitted 1991 by R. Pezzarossa, SIAGI Spa, Rome.

Rome-223. Lago Lungo, 2.25–2.65 m deep **990 ± 65** $\delta^{13}C = -26.4‰$

Carbonaceous clay, 1.32% organic carbon.

Rome-224. Lago Lungo, 2.65–3.00 m deep **1070 ± 60**

Carbonaceous clay, 1.25% organic carbon. *$\delta^{13}C$ = −25.8‰*

Rome-225. Lago Lungo, 5.00–5.50 m deep **4000 ± 70**

Fine, dark brown carbonaceous clay, 0.62% organic carbon. *$\delta^{13}C$= −26.1‰*

Rome-238. Lago Lungo, 5.50–6.00 m deep **3820 ± 70**

Carbonaceous clay, 0.69% organic carbon. *$\delta^{13}C$= −26.6‰*

Rome-226. Lago Lungo, 6.88–7.25 m deep **3800 ± 70**

Carbonaceous clay, 0.74% organic carbon. *$\delta^{13}C$= −25.8‰*

Rome-239. Lago Lungo, 7.25–7.75 m deep **3480 ± 70**

Carbonaceous clay, 0.49% organic carbon. *$\delta^{13}C$= −27.0‰*

Rome-227. Lago Lungo, 7.75–8.25 m deep **3650 ± 70**

Carbonaceous clay, 0.71% organic carbon. *$\delta^{13}C$= −27.7‰*

Rome-228. Lago Lungo, 14.25–14.75 m deep **3580 ± 70**

Carbonaceous clay, 0.77% organic carbon. *$\delta^{13}C$= −27.4‰*

Rome-237. Lago Lungo, 14.75–15.25 m deep **3680 ± 70**

Carbonaceous clay with scattered peat, 0.84% organic carbon. *$\delta^{13}C$= −25.7‰*

Rome-229. Lago Lungo, 21.35–22.25 m deep **12,950 ± 130**

Dark brown peaty clay, 2.35% organic carbon. *$\delta^{13}C$= −30.9‰*

Rome-236. Lago Lungo, 22.25–22.75 m deep **13,350 ± 140**

Dark brown peaty clay, 2.79% organic carbon. *$\delta^{13}C$= −30.0‰*

Rome-230. Lago Lungo, 22.75–23.25 m deep **12,720 ± 130**

Dark brown peaty clay, 6.11% organic carbon. *$\delta^{13}C$= −26.8‰*

Rome-235. Lago Lungo, 23.25–23.75 m deep **11,740 ± 120**

Dark brown peaty clay, 7.39% organic carbon. *$\delta^{13}C$= −27.9‰*

Rome-231. Lago Lungo, 25.60–25.85 m deep **7650 ± 90**

Humified fragments of wood. *$\delta^{13}C$= −28.1‰*

Rome-234. Lago Lungo, 25.85–26.05 m deep **7210 ± 90**

Humified fragments of wood. *$\delta^{13}C$= −27.6‰*

Rome-232. Lago Lungo, 26.25–26.75 m deep **9310 ± 100**
$\delta^{13}C = -27.8‰$

Carbonaceous clay, 6.11% organic carbon.

Rome-199. Lago Lungo, 28.45–28.80 m deep **38,700 ± 2500**
$\delta^{13}C = -25.2‰$

Carbonaceous clay, 0.28% organic carbon.

Rome-233. Lago Lungo, 30.90–31.05 m deep **>43,000**
$\delta^{13}C = -27.5‰$

Carbonaceous clay, 2.62% organic carbon.

Rome-181. Lago Lungo, 40.02–40.30 m deep **>44,000**
$\delta^{13}C = -22.0‰$

Humified fragments of wood.

Rome-182. Lago Lungo, 61.57–61.83 m deep **>43,000**
$\delta^{13}C = -24.8‰$

Humified fragments of wood.

Rome-183. Lago Lungo, 68.38 m deep **>44,000**
$\delta^{13}C = -26.1‰$

Humified fragments of wood.

Comment: Dates for the core samples from 26.30–26.40 and 36.10–36.20 m depth were previously reported (Rome-146 and -147: 8090 ± 100 and >41,000, respectively, Calderoni and Petrone (1992)). Figure 1 shows a profile of the core. ^{14}C ages and sedimentological features, along with malacological and pollen assemblages, revealed a complex pattern of sediment deposition. During the Upper Pleistocene, sedimentation occurred under steppic conditions, accompanied by an arid and cold climate; then, following morphological changes in the basin produced by neotectonic events, the deposited sediments underwent erosion, as recorded by an evident planation surface at a depth of *ca.* 28 m. This feature suggests that the striking age difference (~29,000 yr) between Rome-232 and -199, only 2 m deeper, reflects a hiatus in the sedimentary sequence rather than a dramatic decline of the sedimentation rate. Subsequently, during the Holocene, the morphology of the area again favored sediment accumulation in the basin (Rome-146, -231, -232 and -234). At *ca.* 7500 BP, a mild, humid climate phase occurred (Fig. 1), giving rise to both forest expansion and a fluviolacustrine environment. At the beginning of this rainy phase, the slopes of the catchment area were not yet forested, permitting an inwash of existing soils into the basin. This inwash introduced into the basin aged organic matter, not syngenetic with the sediment layers where it was trapped (soil humic matter, especially in B horizons, may yield ^{14}C ages of many thousands of years). Therefore I would argue that the chronostratigraphical reversal shown by Rome-229, -230, -235 and -236, at depths of 21.35–23.75 m, reflects the origin of the soils' organic matter rather than processes of reworking and/or (bio)chemical fractionation during sediment diagenesis. Finally, ^{14}C ages show that the uppermost 12 m of the sedimentary suite was deposited at a high rate, comparable to that of floodplains.

Upper Adriatic Sea Series

Marine sediments from 8–21 m water depth were collected with a Van Veel grab in the Gulf of Venice during the ATA89 cruise of *R/V D'Ancona* (CNR). We made measurements to investigate the origin and residence time of organic matter trapped by nearshore basal sediments, and to depict the dispersion pattern for solid input carried to the sea by the Isonzo, Tagliamento, Piave, Brenta and Adige Rivers (Calderoni *et al.* 1992). Locations of the 25 sampling stations are shown on Figure 2;

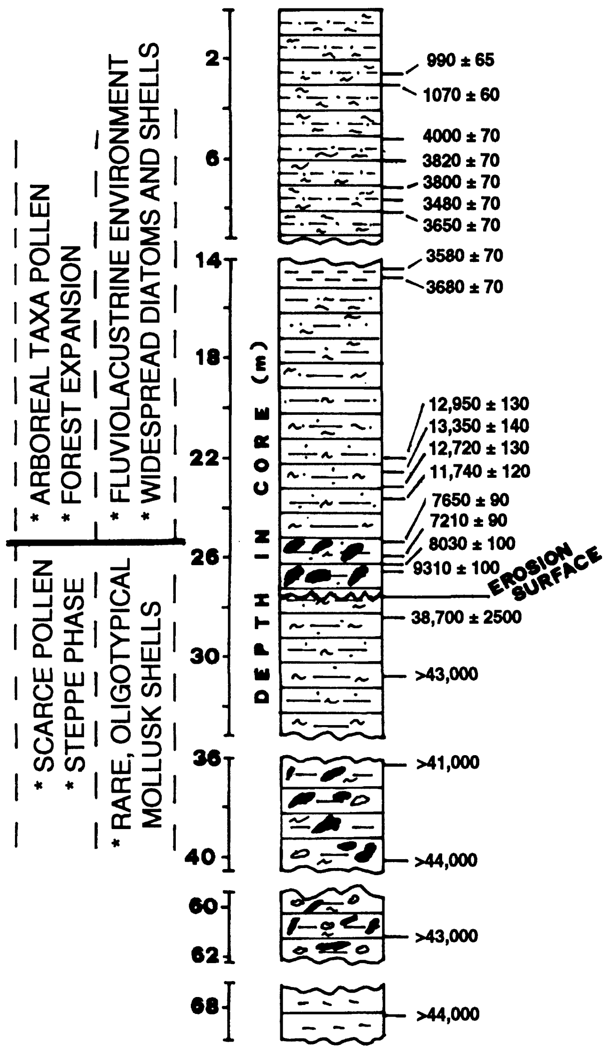

Fig. 1. Diagram of the Lago Lungo core log, showing ^{14}C ages along with palynologic and malacologic data

corresponding station ID numbers in Table 1 are given with the prefix ATA-89. Collected and submitted 1990 by M. Ravaioli, Istituto per la Geologia Marina (CNR) Bologna.

Comment: Sediment samples, ranging from 2 to 4 kg in weight, were previously dried at 60° C, homogenized by grinding and hydrolyzed for 30 min at boiling temperature with 12% HCl to remove carbonate and acid-soluble organics. The ratio between the organic carbon and the clay content in sediments is fairly constant; the organic carbon varies between 0.15 and 1.11%.

Since the last postglacial sea-level rise, the Adriatic continental shelf receives considerable amounts of organic carbon transported by numerous rivers from areas subject to intensive human activity. Thus, both continental shelf and associated estuaries act as primary sinks for the flux of terrestrial carbon. Dispersion of the terrestrially derived organic carbon is hardly documented for the study area, this precluding understanding of organic carbon storage during the Holocene. $\delta^{13}C$ values of organic matter range from −22.6 to −26.2‰ (mean = −24.5 ± 0.8‰). Assuming a mean $\delta^{13}C$ value of −28‰ for riverine particulate organic carbon supplied to the area (Faganeli *et al.* 1990) and of −21‰ for marine-derived organic carbon, marine production contributes significantly to the carbon budget, probably because of nutrient-enhanced sea pollution. Our results show that organic matter in offshore samples is generally less ^{13}C-depleted than in samples close to estuaries. All samples were significantly ^{14}C-depleted (from −167.9 to −349.3‰, this corresponding to apparent ages from 1430 to 3410 BP, respectively) relative to modern carbon. ^{14}C depletion maximizes close to the coast, whereas organic matter from prodelta areas is generally higher in ^{14}C.

Upper Valtellina Series

We studied paleosols (PA) buried either by inactive (*e.g.*, in recession) and active (*e.g.*, in expansion) rock glaciers or morainic deposits laid down by former glaciers. We sampled PA from five sites, 2115–2890 m asl, in Upper Valtellina, Sondrio, Italian Alps, to establish a systematic chronology of glacial phases throughout the area (Calderoni *et al.,* 1993). Samples were collected and submitted 1991 by M. Guglielmin and C. Tellini, Institute of Geology, Paleontology and Geography, University of Parma.

TABLE 1. Upper Adriatic Sea Series

Lab no. (Rome-)	Station ID no.	Depth (m)	Lat (N)	Long (E)	$\delta^{13}C$(‰)	$\Delta^{14}C$(‰)
271	ATA89#01	10	45°44′50″	13°35′00″	−25.3	−185.8 ± 6.9
272	ATA89#02	8	45°37′57″	13°06′40″	−25.1	−318.7 ± 6.2
273	ATA89#03	14	45°37′03″	13°08′20″	−25.0	−243.5 ± 6.5
274	ATA89#05	8	45°37′57″	13°06′02″	−26.1	−349.3 ± 6.1
275	ATA89#06	15	45°36′30″	13°06′32″	−24.7	−167.8 ± 7.1
276	ATA89#08	8	45°37′56″	13°05′14″	−23.8	−339.8 ± 6.1
277	ATA89#09	10	45°36′33″	13°04′54″	−25.1	−221.8 ± 6.8
278	ATA89#10	13	45°35′42″	13°04′54″	−23.9	−255.8 ± 6.6
279	ATA89#11	12	45°36′18″	12°59′48″	−24.0	−248.2 ± 6.7
280	ATA89#11A	12	45°35′49″	13°00′19″	−23.7	−303.2 ± 6.3
281	ATA89#12	11	45°35′10″	13°00′45″	−24.3	−216.0 ± 6.8
282	ATA89#16	12	45°31′10″	12°45′43″	−26.2	−340.8 ± 8.5
283	ATA89#17	16	45°30′08″	12°46′38″	−24.5	−290.9 ± 6.4
284	ATA89#18	19	45°29′15″	12°46′56″	−22.9	−282.9 ± 8.7
285	ATA89#19	15	45°22′33″	12°27′20″	−23.9	−243.1 ± 6.8
286	ATA89#20	9	45°10′37″	12°31′41″	−23.8	−250.6 ± 9.1
287	ATA89#23	21	45°10′00″	12°23′20″	−24.1	−260.1 ± 6.6
288	ATA89#24	20	45°10′06″	12°22′31″	−24.7	−273.0 ± 6.6
289	ATA89#25	16	45°10′26″	12°21′00″	−25.2	−167.9 ± 7.5

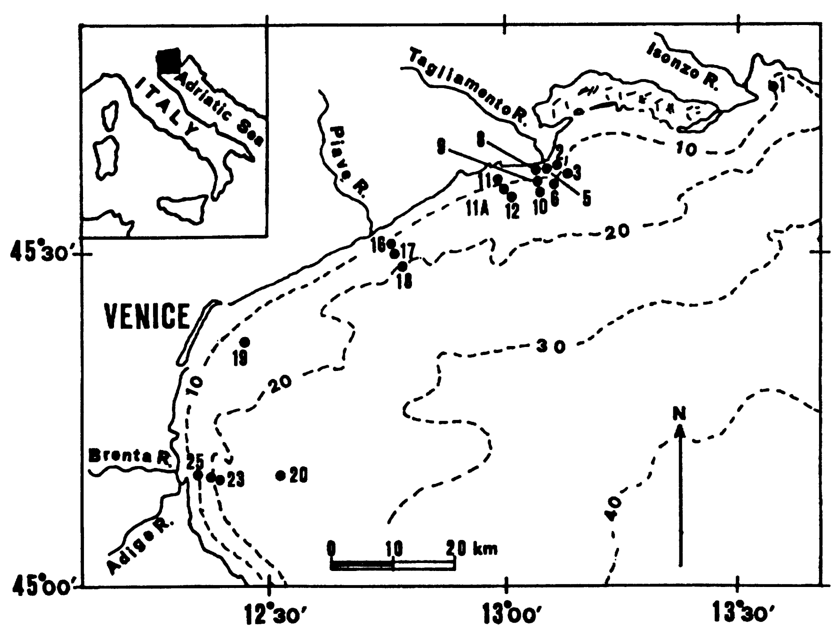

Fig. 2. Locations of ATA89 sampling stations

Rome-200. RGL-1a **790 ± 60**
$\delta^{13}C = -27.6‰$

Whole PA, 10 cm thick, buried by La Foppa I active rock glacier (46°28′40″N, 14°42′53″E) and overlying a morainic Holocene ridge.

Rome-202. RGL-2a **770 ± 60**
$\delta^{13}C = -27.2‰$

Uppermost 1 cm, same as above.

Rome-201. RGL-1b **620 ± 65**
$\delta^{13}C = -27.5‰$

Whole PA, 15 cm thick, buried by La Foppa I active rock glacier, sampled *ca.* 100 m away from Rome-200.

Rome-203. RGL-2b **580 ± 60**
$\delta^{13}C = -27.0‰$

Uppermost 1 cm of same as above PA.

Rome-204. RGL-3 **5000 ± 70**
$\delta^{13}C = -25.1‰$

Whole PA, 7 cm thick, underlying La Foppa II inactive rock glacier (46°28′30″N, 14°43′13″E).

Rome-205. RGL-4 **3330 ± 70**
$\delta^{13}C = -26.3‰$

Whole PA, 15 cm thick, from beneath a postglacial moraine at Foscagno Pass (46°29′54″N, 14° 42′24″E).

Rome-206. RGL-4a **3430 ± 70**
$\delta^{13}C = -26.6‰$

Uppermost 1 cm, same as above.

Rome-207. RGL-5 **1340 ± 65**
$\delta^{13}C = -26.8‰$

Whole PA, 15 cm thick, buried by an active rock glacier at Campo Valley (46°25′58″N, 14°49′ 06″E).

Rome-208. RGL-6 **2200 ± 60**
$\delta^{13}C = -26.4‰$

Whole PA, 7 cm thick, from beneath Mt. Foscagno active rock glacier (46°28′27″N, 14°41′49″E).

Rome-209. RGL-7 **2700 ± 70**
$\delta^{13}C = -26.2‰$

Whole PA, 12 cm thick, buried by an inactive rock glacier at Mt. Foscagno (46°28′32″N, 14°41′ 31″E).

Comment: All ages were measured on bulk humic matter following PA hydrolysis with 6N HCl. According to simplified glacial timescales of Heuberger (1968), Mair (1968) and DeGraaf, Kuijper and Slotboom (1989), ^{14}C ages suggest that the area experienced the following glacial stages:

Larstig (La Foppa II site, Rome-204); Goschenen I (Mt. Foscagno and Foscagno Pass sites, Rome-208, -209 and Rome-205, -206, respectively); Goschenen II (Campo Valley site, Rome-207); 13–15th centuries cold phase, *e.g.,* Little Ice Age (La Foppa I site, Rome-200 to -203).

Conca River Series

Two well-preserved flooded wooden fragments exposed by natural stream erosion in the coastal alluvial plain of the Conca River, *ca.* 20 km west of the Adriatic Sea, at the Tombaccia site (Romagna, northern Italy). For detailed geological and geomorphological descriptions of the study area, see Elmi, Nesci and Tentoni (1991 and references therein). Collected and submitted July 1991 by C. Elmi, Department of Geology, University of Bologna.

Rome-178. Conca River A **>43,000**

Dark brown fragment from lacustrine sediments, rich in remains of plant debris and terrestrial shells, underlying fluviatile sediments (43°56′17″N, 12°41′02″E).

Rome-179. Conca River B **>43,000**

Dark brown fragment, *ca.* 100 m upstream and 3.80 m higher than Rome-178, from sandy-clayey-pebbly lenses and thin layers of fluviatile sediments (43°56′16″N, 12°40′56″E).

Comment: Samples are from a continental sediment suite including two units separated by an erosion surface. The lower fluviolacustrine unit contains either *in-situ* or reworked tree trunks from >43,000 BP, whereas samples from the upper, mainly fluviatile unit were previously dated at 32,000–35,000 BP (Forlani 1987). Dates constrain the deposit age to cold phases of the Late Würm.

Metauro River Series

Wooden fragments from alluvial terrace deposits in the middle Metauro River basin. Collected and submitted 1990 by D. Savelli and O. Nesci, Institute of Geology, University of Urbino.

Rome-184. Metauro River S#9 **>43,000**

Dark, well-preserved samples spread over the base of the "3rd-order" (Würm) terrace alluvium exposed on a quarry wall at St. Stefano di Gaifa, north bank of the Metauro River, Pesaro, Marchean Apennines (43°41′13″N, 12°42′49″E).

Rome-215. Tarugo stream TRG#1 >44,000

Dark sample from a lens-shaped, fine-grained alluvial deposit representing a buried "3rd-order" terrace exposed near the confluence of the Feccia and Tarugo streams, both tributaries of the Metauro River, Pesaro (43°40′20″N, 12°51′02″E).

Rome-197. Burano stream S#7 **>43,000**

Rome-198. Burano stream S#8 **>43,000**

Well-preserved samples from the lowermost 4 m of a 20-m-thick alluvial deposit exposed on the north bank of the Burano stream, a tributary of Metauro River, *ca.* 5 km SE of Cagli (43°30′02″N, 12°41′23″E).

Comment: These samples were measured as part of continuing research on the evolution of terrace deposits in the central Apennines. Dates do not conflict with those previously measured (R-1614, >41,000 BP) for a fragment of *Pinus sylvestris* from the comparable outcrop at Il Barco site nearby (Alessio *et al.* 1987).

Miscellaneous Samples

Rome-175. Forni di Sotto — 9860 ± 100

Wooden fragment 3 m deep in Holocene lacustrine clay from Forni di Sotto, 692 m asl, close to the south bank of the Tagliamento River, Udine, northern Italy (46°23′08″N, 12°42′12″E). Collected and submitted 1990 by M. Martinis, Department of Earth Sciences, University of Rome. We conclude that the lacustrine clay was deposited following the damming of the Tagliamento River by landslide(s) triggered by the receding Tagliamento glacier.

Rome-176. Case Lendra — >43,000

Dark brown, 20-cm-thick and 7-m-deep peat-rich clayey layer from a 10-m-long sediment core drilled at Case Lendra, south of Sassoferrato, Ancona, central Italy (43°25′31″N, 12°05′22″E). Collected and submitted 1991 by G. Pambianchi, Institute of Geology, University of Camerino. The sample is from the transition between 2nd- and 3rd-order alluvial sediments, both resting on a base of clayey-marlaceous terranes assigned to the Schlier formation. Dates the development of marshy conditions throughout the area.

Rome-177. Middle Cesano River Basin SN#3 — 40,000 ± 3000

Reworked wooden fragment, underlying braided-stream sediments laid down by the Cesano River, exposed by quarry operations at St. Michele al Fiume, south bank of the Cesano River, Marchean Apennines (43°39′37″N, 12°59′43″E). Collected and submitted 1991 by O. Nesci and D. Savelli. Three previous ages for wood samples from the same site (Calderoni and Petrone 1992) range from 32,500 to 37,300 BP. The new date extends significantly the aggradation phase of braided-stream sediments through the central Apennines.

Rome-290. Colle Caprara — >43,000

Bulk organic carbon from a PA interbedded in alluvial sediments tentatively assigned to the 2nd-order terrace, exposed by quarry operations at Colle Caprara, south bank of Pescara stream, Pescara, central Italy (42°26′06″N, 14°07′25″E). Collected 1991 by G. Calderoni and D. De Rita, Department of Earth Sciences, University of Rome. ^{14}C dating of humic acids recovered from the same PA by exhaustive NaOH extraction following complete decarbonation (Rome-291) yielded a similar result, confirming that the younger PA humic matter is also too old to be dated.

References

Alessio, M., Allegri, L., Azzi, C., Calderoni, G., Cortesi, C., Improta, S., Nesci, O., Petrone, V. and Savelli, D. 1987 Successioni alluvionali terrazzate nel medio bacino del Metauro (Appennino Marchigiano)—Datazione con il ^{14}C. *Geografia Fisica e Dinamica Quaternaria* 10: 307–312.

Alessio, M., Allegri, L., Azzi, C., Calderoni, G., Cortesi, C., Improta, S. and Petrone, V. 1989 ^{14}C tephrochronology with different fractions of paleosol humic matter at Procida island, Italy. *In* Long, A., Kra, R. S. and Srdoč, D., eds., Proceedings of the 13th International ^{14}C Conference. *Radiocarbon* 31(3): 664–671.

Ballario, C., Beheventano, M., De Marco, A., Magistrelli, F., Cortesi, C. and Mantovani, T. 1955 Apparatus for carbon-14 dating. *Science* 121: 409.

Bonatti, E. 1968 Late-Pleistocene and postglacial stratigraphy of a sediment core from the lagoon of Venice (Italy). *Memorie di Biogeografia Adriatica, Supplemento* 7: 1–18.

Calderoni, G., Frignani, M., Langone, L., Petrone, V. and Ravaioli, M. 1992 The distribution of ^{14}C and ^{13}C in the organic fraction of coastal sediments from the northern Adriatic Sea. *Proceedings of the 23rd Congress and Plenary Assembly of ICSEM* 33(1): 380.

Calderoni, G., Guglielmin, M., Lozej, A. and Tellini, C. (ms.) 1993 Research on rock glaciers in the central Italian Alps (Valtellina, Sondrio, northern Italy). Paper presented at the 6th International Conference on Permafrost, July 5–9, 1993, Beijing, China.

Calderoni, G. and Petrone, V. 1992 Department of Earth Sciences at the University of Rome radiocarbon dates I. *Radiocarbon* 34(1): 105–113.

De Graaf, L. W. S., Kuijper, W. J. and Slotboom, R. T. 1989 Schlubvereisung und spatglaziale Entwicklung des Moorgebietes Gasserplatz (Feldkirch-Gofis, Vorarlberg). *Jahrbuch der Geologischen Bundesanstalt* 132(2): 397–413.

Elmi, C., Nesci, O. and Tentoni, L. 1991 La piana del T. Conca e le pianure minori nord-Marchigiane: Forme, depositi ed evoluzione. *Geografia Fisica e Dinamica Quaternaria* 14(1): 113–117.

Faganeli, J., Pezdic, J., Ogolerec, B. and Misic, M. 1990 Source of sedimentary organic matter in the Adriatic sea. *Proceedings of the 22nd Congress and Plenary Assembly of ICSEM* 32(1): 284.

Forlani, E. (ms.) 1987 Studio idrogeologico della conoide e fattibilità di un canale deviatore della diga del F. Conca. Technical Report, Municipality of Emilia-Romagna.

Heuberger, H. 1968 Die Alpengletscher in Spät- und Postglazial. *Eiszeitalter und Gegenwart* 19: 270–275.

Lenaz, R. and Taviani, M. 1986 Differentiated subsidence of the upper Adriatic area facing Venice (45°11′ – 45°21′ lat. N) as revealed by ^{14}C datings of late Pleistocene peats. *In* Johnson, A. I., Carbonin, L. and Ubertini, L., eds., *Land Subsidence: Proceedings of the 3rd International Symposium on Land Subsidence.* Wallingford, Oxfordshire, UK, International Association of Hydrological Sciences: 359–365.

Mair, R. 1968 Postglacial glacier fluctuations and correlative phenomena in the Stubai Mountains, Eastern Alps, Tyrol. *Earth Sciences* 7: 167–177.

Stuiver, M. and Polach, H. A. 1977 Discussion: Reporting of ^{14}C data. *Radiocarbon* 19(3): 355–363.