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RUDJER BOŠKOVIĆ INSTITUTE RADIOCARBON MEASUREMENTS V

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The following list contains dates of samples measured since our previous list (R, 1977, v 19, p 465-475). As before, age calculations are based on the Libby half-life, 5570 ± 30 years, and reported in years before 1950. The modern standard is 0.95 of the activity of NBS oxalic acid. Solid sample pretreatment, combustion and counting technique are essentially the same as described in R, 1971, v 13, p 135-140. Groundwater samples were prepared following the procedure adopted by the IAEA (IAEA, 1977). Carbonates and hydrocarbonates from water samples were precipitated by adding saturated barium chloride solution while the alkalinity was adjusted to pH = 8 by adding carbonate-free saturated solution of sodium hydroxide. The precipitation was enhanced by adding iron salts and Praestol as coagulating medium. Carbon dioxide was evolved by acidification of the precipitate and converted to methane. Statistical processing of data has been computerized (Obelić and Planinić, 1975). Sample descriptions were prepared with collectors and submitters. The errors quoted correspond to 1σ variation of sample net counting rate and do not include the uncertainty in ^{14}C half-life.

Results were corrected for isotopic fractionation using measured $^{13}C/^{12}C$ ratios for groundwater samples and estimated values (Stuiver & Polach, 1977) for all other samples. Calculations of ages or percent of modern of speleothems and groundwaters are based on the initial activity of reservoirs equal to 65% or 85% of modern standard (i.e. 95% activity of NBS oxalic acid) depending on the geology of the catchment area (Münnich & Vogel, 1959; Geyh, 1972; Job *et al*, 1975; Sonntag *et al*, 1976).

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SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

Kozlerjeva Gošča series

Peat and lake marl from bore hole at Kozlerjeva Gošča (46° 1′ 0″ N, 14° 30′ 46″ E) SE part of Ljubljansko Barje, Slovenia. Dated to deter-

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mine postglacial vegetation development and transition of lake to peat bog. Coll and subm 1976 by A Šercelj, Fac Arts Sci Ljubljana. *Comment* (AŠ): dates agree well with pollen analysis.

Z-506. Kozlerjeva Gošča **2170 ± 120**
$\delta^{13}C = -27‰$

80 to 100cm depth.

Z-507. Kozlerjeva Gošča **4240 ± 130**
$\delta^{13}C = -27‰$

220 to 235cm depth.

Z-508. Kozlerjeva Gošča **2970 ± 120**
$\delta^{13}C = -27‰$

130 to 160cm depth.

Z-509. Kozlerjeva Gošča **3310 ± 120**
$\delta^{13}C = -27‰$

190 to 210cm depth.

Z-510. Kozlerjeva Gošča **4510 ± 120**
$\delta^{13}C = -27‰$

290 to 320cm depth.

Z-526. Bezdanjača Cave **3310 ± 90**
$\delta^{13}C = -8‰$

Botryoid, clustered calcite deposit on wall of Hall of Deaf in Bezdanjača cave near Vrhovine (44° 50′ N, 15° 23′ E) Lika, Croatia. Dates variations of water level in cave. Initial content of reservoir: 85% of modern standard.

Z-543. Anhovo **18,980 ± 310**
$\delta^{13}C = -24‰$

Wooden fragments from lake marl profile at village Anhovo (46° 3′ 40″ N, 13° 39′ 0″ E) Slovenia. Dating of lake marl embedded in conglomerate terrace of older Würm was to determine age of terrace. Coll 1977 by Metka Culiberg and subm by A Šercelj, Slov Acad Arts, Ljubljana.

Z-544. Račje selo **1880 ± 120**
$\delta^{13}C = -27‰$

Peat from 245cm deep bore hole at village Račje selo (45° 55′ 40″ N, 15° 0′ 30″ E) near Trebnje, Slovenia. Dates beginning of peat-bog growth. *Comment* (AŠ): expected age: Holocene.

II. ARCHAEOLOGIC SAMPLES

Šandalja II series

Charcoal from hearth in Šandalja cave, limestone quarry (44° 52′ 57″ N, 13° 53′ 48″ E) near Pula, Istra, W Croatia. Assoc with Aurignacian artifacts of Lautsch type in Stratum F and in upper part of Stratum G

(Malez & Vogel, 1969). Coll and subm 1976 by M Malez, Yugoslav Acad Sci Arts, Zagreb.

Z-536. Šandalja **27,800 ± 800**
$\delta^{13}C = -24‰$

Charcoal from hearth, SW part of hall, Stratum G, reddish brown sandy loam with stone, 5.5 to 6m depth.

Z-537. Šandalja **22,660 ± 460**
$\delta^{13}C = -24‰$

Charcoal from hearth, S part of hall, Stratum F, yellowish red to yellowish brown sandy loam, 40 to 50cm depth.

Z-551. Vindija **27,000 ± 600**
$\delta^{13}C = -24‰$

Charcoal from Stratum 6 in Vindija Cave, Gornja Voća near Ivanec, N Croatia. Systematic investigations of Quarternary period in Vindija Cave. Dates Paleolithic culture of Aurignacian and accompanied fauna. Coll and subm 1977 by M Malez. *Comment* (MM): agrees with expected age.

Vranjičko Blato series

Fragments of wooden beam (*Pinus halepensis*) submerged in swamp Vranjičko Blato, site of Roman harbor, near Solin (Salona) (43° 13′ N, 16° 13′ E), Croatia. Coll and subm 1976 by N Cambi, Archaeol Mus, Split. *Comment* (NC): expected age: 1st century AD.

Z-519. Vranjičko Blato 1 **2060 ± 100**
$\delta^{13}C = -24‰$

Z-520. Vranjičko Blato 2 **2110 ± 100**
$\delta^{13}C = -24‰$

Z-521. Vranjičko Blato 3 **2130 ± 90**
$\delta^{13}C = -24‰$

Z-522. Gradić **1335 ± 90**
$\delta^{13}C = -24‰$

Wooden beam (*Quercus* sp) 1.2m below alluvial soil, Torčec near Koprivnica (46° 8′ N, 16° 50′ E) N Croatia. Assoc with abundant ceramic fragments, bone artifacts and burned bricks. Coll and subm 1976 by B Januška. *Comment* (BJ): expected age: Early Middle age.

Parti series

Wooden fragments of pile dwellings from Eneolithic cultural layer, 1m below surface at Parti, SE part of Ljubljansko Barje peat bog (45° 58′ 20″ N, 14° 32′ 20″ E) Slovenia. Dates pile-dwelling settlements in Lj Barje area (R, 1975, v 17, p 149; R, 1977, v 19, p 465). Coll 1976 by Tatjana Bregant, Fac Arts Sci, Ljubljana and subm by A Šercelj. *Comment* (AŠ): expected age: 4000 yr.

Z-539. Parti No. 16 **3920 ± 100**
$\delta^{13}C = -24‰$

Z-540. Parti No. 81 **4010 ± 100**
$\delta^{13}C = -24‰$

Libna series

Fragments of wooden beams from fortress wall at Libna village near Krško (45° 57′ N, 15° 32′ E) alt 359m, Slovenia. Dates construction of prehistoric settlement (Guštin, 1976). Coll and subm 1976 by M Guštin, Posavski Mus Brežice, Slovenia.

Z-541. Libna 1 **3015 ± 95**
$\delta^{13}C = -24‰$

Fragment of wooden beam 2m below surface. *Comment* (MG): date seems too old.

Z-542. Libna 2 **2565 ± 85**
$\delta^{13}C = -24‰$

Fragment of wooden beam 2.5m below surface in deepest cultural phase of settlement assoc with prehistoric ceramic. *Comment* (MG): agrees with expected age.

Z-564. Orešje **2370 ± 85**
$\delta^{13}C = -24‰$

Wooden board from cultural layer 25cm below surface, Orešje na Bizeljskom, 500m alt (46° 3′ N, 15° 43′ E) Slovenia. Dates cultural layer. Coll and subm 1977 by M Guštin, Posavski Mus, Brežice, Slovenia.

Ljuljaci series

Charcoal from cultural strata assoc with pottery at Ljuljaci village near Kragujevac (44° 1′ N, 20° 40′ E), Central Serbia. Dates development of cultural phases of Early and Middle Bronze age in Central Serbia and helps to solve some problems of Western Serbian variant of Vatin culture. Coll and subm by Zagorka Letica, Fac Arts Sci, Archaeol Dept, Belgrade. *Comment* (ZL): 1st half of 2nd millennium BC.

Z-545. Ljuljaci (No. 10) **3425 ± 95**
$\delta^{13}C = -24‰$

Sonda VIII/a, Excavation Layer V.

Z-546. Ljuljaci (No. 8) **3480 ± 100**
$\delta^{13}C = -24‰$

Sonda VIII, Zona II, Excavation Layer III.

Z-547. Ljuljaci (No. 1) **1195 ± 90**
$\delta^{13}C = -24‰$

Sonda VI/a, Excavation Layer I, 36cm below surface.

Z-548. Ljuljaci (No. 16) **3460 ± 100**
$\delta^{13}C = -24‰$

Sonda VIII, Excavation Layer VI near hearth, 82cm below surface.

Z-549. Ljuljaci (No. 12) **3370 ± 100**
$\delta^{13}C = -24‰$

Sonda VI/a, Excavation Layer IV.

Z-563. Trg **Modern ($\Delta^{14}C = -14‰$)**
$\delta^{13}C = -25‰$

Fragment of axe-hewn log boat (*Quercus robur*) buried in muddy bed of Kupa R near Ozalj (45° 37′ N, 15° 30′ E). Coll and subm by H Malinar. *Comment* (NM): expected age: 100 to 300 yr.

Z-553. Slavonski Brod **240 ± 80**
$\delta^{13}C = -25‰$

Fragment of axe-hewn log boat (*Quercus robur*) buried in muddy bed of Sava R near Slavonski Brod (45° 10′ N, 18° 2′ E). Coll and subm 1977 by H Malinar and B Vrbek, Croatian Inst Restoration, Zagreb.

Zlarin series

Fragments of wooden ship under 15cm thick sandy layer, 32m below sea surface, off Zlarin I. (43° 40′ 30″ N, 15° 52′ 20″ E) near Šibenik, S Croatia. Dates antique ship. Coll and subm 1977 by Z Brusić, Šibenik Mus. *Comment* (ZB): expected age: ca 2000 yr.

Z-567. Zlarin **2235 ± 85**
$\delta^{13}C = -24‰$

Fragment of rib (*Castanea sativa* or *Quercus* sp).

Z-568. Zlarin **2245 ± 90**
$\delta^{13}C = -24‰$

Fragment of hull (*Picea* sp).

Z-571. Gradina **2010 ± 95**
$\delta^{13}C = -24‰$

Fragment of wooden beam, 80cm below sandy and muddy layer, 200cm below sea surface, Zaton near Nin (44° 14′ N, 15° 20′ E). Dates antique harbor Aenone (Z Brusić, 1969). Coll and subm 1977 by Z Brusić, Archaeol Mus, Zadar. *Comment* (ZB): expected age: ca 2000 yr.

III. HYDROGEOLOGIC SAMPLES

Libyan water series

Isotopic analyses of water samples from Libya have been made as part of complex hydrogeol study performed by Energoprojekt, Belgrade, in Tripolitania, Libya, between 28° 45′ and 32° 20′ N, and 12° 00′ and 16° 20′ E, including confluences of temporary surface flows (wadis) Sawfajjin, Zamzam, Bay al Kabir and Jufrah region. Radiocarbon measurements and other isotopic analyses (tritium, deuterium and ^{18}O) resulted in valuable information for planning and development of exploitation of groundwaters in arid and desert regions of Tripolitania (Zogović & Filipovski, 1978; Obelić *et al*, 1978). Samples were coll from March 1975 to February 1976 by Energoprojekt experts and chemically

Table 1

Sample No.	Well Name	Water Depth (m)	Location N Lat	Location E Long	$\delta^{13}C$ (± 0.05)	^{14}C Percent Modern	^{14}C Apparent Age (yr)	Aquifer
Z-443	WS-10	172	31° 10′	15° 06′	−3.77	3.8 ± 0.5	26,300 ± 900	Eocene
Z-446	WS-21	75	31° 17′	15° 11′	−3.77	4.8 ± 0.5	24,300 ± 800	Eocene
Z-442	WS-1	130	30° 52′	15° 19′	−2.17	2.3 ± 0.5	30,200 $^{+1600}_{-1500}$	Eocene
Z-465	Hun Old Well	445	29° 05′	15° 55′	−6.17	1.8 ± 0.5	32,400 $^{+1900}_{-1800}$	Eocene
Z-474	Abu Nujaym 1	450	30° 35′	15° 27′	−3.88	<0.6	>40,000	Eocene (Paleocene)
Z-473	Abu Nujaym 2	450	30° 35′	15° 27′	−2.39	<0.6	>40,000	Eocene
Z-466	Socna 4	180	29° 04′	15° 50′	−4.77	1.4 ± 0.5	34,100 $^{+2300}_{-2200}$	Socna
Z-467	Socna 2	202	29° 04′	15° 50′	−4.29	2.0 ± 0.5	31,300 $^{+1700}_{-1700}$	Socna
Z-468	Socna 11	150	29° 04′	15° 50′	−4.18	<0.6	>40,000	Socna
Z-472	Ferjan J − 3T	332	28° 55′	15° 38′	−4.77	2.3 ± 0.5	30,200 $^{+1500}_{-1500}$	Socna
Z-463	Nesma 2	70	31° 02′	13° 25′	−5.47	24.7 ± 0.6	11,200 ± 190	Tigrinna
Z-464	No. 22	80	31° 02′	13° 25′	−1.49	6.5 ± 0.5	21,900 ± 600	Tigrinna
Z-470	WS-9	500	31° 34′	14° 23′	−6.86	23.0 ± 0.6	11,730 ± 200	Mizdah
Z-460	Bani Walid (271)	300	31° 45′	14° 04′	−3.78	12.8 ± 0.5	16,500 ± 300	Gharyan
Z-462	Bir Sanam	450	31° 21′	13° 41′	−1.19	2.9 ± 0.5	28,300 ± 1200	Gharyan
Z-448	GW-7 Garabulli	—	32° 44′	13° 45′	−2.67	<0.6	>40,000	Gharyan
Z-441	ZZ-1	1000	31° 09′	15° 03′	−5.47	1.7 ± 0.5	32,600 $^{+2000}_{-1900}$	Chiclah
Z-459	ZZ-2	1000	31° 10′	15° 05′	−5.42	2.2 ± 0.3	30,700 $^{+1200}_{-1100}$	Chiclah
Z-469	Well Nura	975	31° 47′	13° 53′	−6.86	<0.6	>40,000	Chiclah
Z-511	WS-2	1010	30° 58′	14° 35′	−4.65	1.2 ± 0.3	35,300 $^{+1600}_{-1500}$	Chiclah
Z-513	WS-4	801	30° 24′	13° 36′	−5.54	<0.6	>40,000	Chiclah
Z-471	WS-14 M	772	31° 27′	13° 00′	−7.46	11.6 ± 0.4	17,300 ± 270	Kabaw
Z-515	WS-8	460	29° 02′	14° 18′	−3.40	5.8 ± 0.3	22,800 ± 400	Paleozoic
Z-518	No. 1	519	29° 20′	15° 22′	−3.35	4.5 ± 0.3	24,900 ± 600	Paleozoic
Z-476	G-XII Garabulli	—	32° 44′	13° 45′	−5.47	14.8 ± 0.5	15,300 ± 270	Azzizia
Z-477	E-IV Garabulli	—	32° 44′	13° 45′	−4.77	2.9 ± 0.4	28,500 ± 900	Azzizia

processed in Tripoli by our staff. $^{13}C/^{12}C$ ratio was measured by D Stefanović, IRB, and simultaneously at GSF, Munnich by W Stichler. Results of measurements are presented in Table 1. Apparent age of water samples is calculated on the basis of initial activity of reservoir equal to 85% of modern standard (95% NBS oxalic acid) and under the assumption that no recharge, mixing or depletion of activity due to isotopic fractionation has taken place.

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