

RUDJER BOŠKOVIĆ INSTITUTE RADIOCARBON MEASUREMENTS XII

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INTRODUCTION

We present here radiocarbon analyses made since our previous list (Srdoč *et al.* 1989). Sample pretreatment, combustion and counting techniques are essentially the same as described previously (Srdoč, Breyer & Sliepčević 1971), supplemented by new techniques for groundwater processing (Srdoč *et al.* 1979). The calculation of ages follows conventional protocol (Stuiver & Polach 1977). These ages can be converted from the 5570-year half-life to the chronometrically more correct half-life of 5730 years by multiplying by the factor, 1.029. Ages and standard deviations of all samples are adjusted for stable isotope fractionation according to the recommendations in Stuiver and Polach (1977), except for groundwater, calcareous deposits and aquatic plants. The $\delta^{13}\text{C}$ values of the latter reflect the environmental conditions during their formation or growth rather than fractionation (Mook 1976; Krajcar Bronić *et al.* 1986; Marčenko *et al.* 1989). Thus, any percent modern (pMC) correction based on $\delta^{13}\text{C}$ values is meaningless or even misleading. Sample descriptions are prepared in collaboration with collectors and submitters. Calibrated ages were calculated using the program of Stuiver and Reimer (1987).

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ARCHAEOLOGICAL SAMPLES

YUGOSLAVIA

Z-1966. Statue of Christ's head

98.9 \pm 0.8 pMC

Sample is from a wooden statue of Christ's head (43 tree rings), from a private collection. Collected and submitted 1987 by V. Lavrenčič, Ljubljana, Slovenia.

Comment: Calibrated range: AD 1686-1955.

Vela spilja series

Charcoal mixed with clay from Vela spilja cave, Korčula Island, 0.85-1.64 m below ground level, near Vela Luka (48°58'N, 16°44'E), 130 m asl, Croatia. Collected and submitted Dec. 1987 by B. Čečuk, Archaeological Institute, Yugoslav Academy of Sciences and Arts, Zagreb.

Z-1968.

6990 \pm 120

Charcoal from Layer 5 above a grave, 0.85-1.12 m depth.

Z-1967. **7300 ± 120**

Charcoal from Layer 6 above the same grave, 1.12–1.64 m depth.

Comment (B.Č.): This was a systematic archaeological investigation of a Neolithic site. The expected age was ~6000 BP. The date from an earlier measurement was Z-1742: 5430 ± 100 (Srdoč *et al.* 1989: 86).

Ajdovska jama cave series

Charcoal from Ajdovska jama cave at Nemška Vas near Krško (45°58'N, 15°30'E), east Slovenia. Collected by M. Horvat, Faculty of Sciences, Ljubljana and submitted 1987 by A. Šercelj, Slovenian Academy of Sciences and Arts, Ljubljana. Samples from a systematic excavation of a Neolithic site. Dates correspond to earlier measurements, Z-1042 to -1045 (Srdoč *et al.* 1984: 451), Z-1178, -1179, -1554, -1602, -1603 (Srdoč *et al.* 1987: 138–139) and Z-1822, -1860 (Srdoč *et al.* 1989: 86).

Z-2042. Ajdovska jama 41/87 **5230 ± 110**

Charcoal from Quadrant 35. Sample was associated with human bones.

Z-2043. Ajdovska jama 34/87 **4820 ± 100**

Charcoal from a brown loose layer, Quadrant 35.

Z-2044. Ajdovska jama 18/87 **4900 ± 100**

Charcoal from a gray ash layer, Quadrant 35.

Z-2123. Ajdovska jama 42 **5360 ± 130**

Charcoal with charred pollen from a central hall, Quadrant 24, Section 12.

Z-2179. Ajdovska jama 19 **5160 ± 130**

Charcoal with charred pollen from Quadrant 39, Section 68.

Comment (D.S.): Z-1603 is an outlier in this series; Z-1822 is a speleothem whose age agrees well with the charcoal age, if we assume the initial ¹⁴C activity, A₀, of speleothems equal to 85 pMC, a pervasive value for A₀ in karst of Dinarides.

Sisak series

Fragments of a charred beam from a building near the Kupa River bank at Sisak (45°30'N, 16°20'E), Croatia. Collected and submitted 1988 by V. Nenadić, Department of Archaeology, Institute of Historical Sciences, University of Zagreb.

Z-2063. Sisak 1 **170 ± 110**

Fragment of a charred beam, 3.85 m depth.

Z-2064. Sisak 2 **20 ± 110**

Fragment of a charred beam, 4.10 m depth.

Comments: (V.N.): Expected age: 250 BP. (D.S.): The expected age is within calibrated range (AD 1675–1955), according to Stuiver and Reimer (1987).

Z-2112. Sisak 1990 ± 120

Fragment of a wooden beam buried in the Kupa River bed, probably from the foundation of a Roman mint. Collected and submitted 1989 by B. Slovenec and G. Grgić, Sisak.

Z-2065. Podsreda 600 ± 80

Remnants of a rotten wooden beam built into the south facade of a stone wall in Podsreda (46°2'N, 15°38'E), near Bistrica ob Sotli. Collected and submitted 1988 by B. Uršić, Regional Institute for Protection of Cultural Monuments, Zagreb.

Comment (B.U.): Expected age: Middle Ages (12th or 13th century).

Z-2096. Vladikina ploča 2650 ± 110

Charcoal from a fireplace in Vladikina ploča cave, Rsovac near Pirot (43°11'26"N, 22°45'17"E), 758 m asl, 20 m from the entrance, covered with 1 to 5-cm-thick calcite flowstone. Collected and submitted 1988 by D. Gavrilović, University of Belgrade.

Comment (D.G.): Expected age: 500 BP. Dates the period of cave occupation. Dates from earlier measurements are Z-1641: 290 ± 100 (Srdoč *et al.* 1989: 85), indicating an extended period of cave occupation.

Brezovica series

Wood fragments from the base of a Roman road at Mala Vas near Brezovica (46°1'N, 14°26'E), 300 m asl, Slovenia. Collected 1988 by T. Bregant, Faculty of Arts and Sciences, Ljubljana and submitted by A. Šercelj.

Z-2098. Mala Vas, VS-10/3 1 780 ± 80

Wood fragments (*Fagus*, *Corylus*, *Populus*) from 130–150 cm depth, Quadrant III.

Z-2099. Mala Vas, VS-10/3 2 580 ± 80

Wood fragment (*Betula*) from 125 cm depth, Quadrant III.

Comment (A.Š.): Expected age: Roman period.

Z-2113. Plav >37,000

Fossil wood (*Juniperus* sp.) from a Pleistocene terrace at Plav (42°35'N, 19°38'E), Montenegro. Collected 1989 by J. Kunaver, Faculty of Arts and Sciences, Ljubljana and submitted by A. Šercelj.

Z-2114. Bukovnica 5650 ± 110

Charcoal from a Neolithic site, Quadrant 224, Mkv 64–66, 74–76 at Bukovnica near Dobrovnik (45°39'N, 16°22'E), 280–300 m asl, 15 km east of Murska Sobota. Collected 1989 by I. Šavelj, Regional Museum, Murska Sobota and submitted by A. Šercelj.

Comment (I.Š.): Expected age: Neolithic.

Z-2125. Statue of King David's head **200 ± 110**

Sample is from a wooden (oak or walnut) statue of King David's head, from a private collection. Collected and submitted 1989 by I. Krtalić, Zagreb.

Zagreb – Grič series

Charcoal from a fireplace, Clarissa monastery, Grič, Upper Town, Zagreb (45°50'N, 16°0'E), 150 m asl, Croatia. Collected and submitted 1989 by N. Majnarić-Pandžić, Department of Archaeology, University of Zagreb.

Z-2130. Zagreb – Grič 1 **660 ± 120**

Charcoal from Pit S, 180–183 cm depth.

Z-2129. Zagreb – Grič 2 **2050 ± 90**

Charcoal from Fireplace A.

Z-2133. Zagreb – Grič 3 **2810 ± 130**

Charcoal from Trench B2/3, 174.8 cm depth.

Comment (N.M.-P.): Expected age: Middle Ages (15th or 16th century).

Z-2159. Barice **2990 ± 90**

Charcoal from a cremation site in the central part of Tumulus I at Barice near Laminci village, Jaružani (45°6'15"N, 17°22'E), 92 m asl, Bosnia. Collected and submitted 1989 by B. Čović, Sarajevo Museum (Đurdjević 1987).

Comment (B.Č.): The tumulus is characteristic of the newly discovered Barice – Gredjani cultural group. Expected age: 3300–3500 BP.

Z-2156. Kistanje **350 ± 100**

Charcoal from the yard of St. Archangels monastery, on the Krka River bank near Kistanje (43°59'N, 16°0'E), Bukovica, Croatia. Collected and submitted 1989 by B. Uršić, Regional Institute for Protection of Cultural Monuments, Zagreb.

Comment (B.U.): Expected age: AD 9 to 13th century.

Kalnik – Igrišće series

Charcoal from systematic excavations of a Late Bronze Age settlement on Mt. Kalnik, Igrišće (46°05'N, 16°27'E), 400 m asl, north Croatia. Collected and submitted 1989 by N. Majnarić-Pandžić.

Z-2160. Kalnik – Igrišće **2540 ± 60**

Charcoal from Hearth 3.

Z-2163. Kalnik – Igrišće A1 A10 **2890 ± 90**

Charcoal, 0.40 m depth.

Z-2161. Kalnik – Igrišće K1 A9 2980 ± 70

Charcoal, 0.59 m depth.

Z-2162. Kalnik – Igrišće K1 B8 2650 ± 60

Charcoal, 1.20 m depth

Comment (N.M.-P.): Expected age: 13th to 11th century BC.

Slavonska Požega series

Wood, bones and charcoal from Sv. Lovro medieval church in Slavonska Požega (45°20'N, 17°41'E), Slavonia, Croatia (Langhamer 1966; Degmedžić 1977; Horvat & Mirnik 1977). Samples were dated to determine the beginning of church construction. Collected and submitted 1989 by I. Srša, Croatian Institute for Restoration, Zagreb.

Z-2168. Slavonska Požega 1 560 ± 80

Wooden scaffolding from inside the western gable. An earlier measurement was Z-1921: 790 ± 100 (Srdoč *et al.* 1989: 86–87).

Comment (I.Š.): Expected age: 700 BP.

Z-2169. Slavonska Požega 2 700 ± 90

Wooden beam, part of western gable.

Comment (I.Š.): Expected age: 700 BP.

Z-2171. Slavonska Požega 3 400 ± 90

Charred wood from the roof or floor, buried in soil at 0.40 m depth.

Comment (I.Š.): Expected age: 500–550 BP.

Z-2172. Slavonska Požega 4 280 ± 80

Wood fragments of a coffin from Trench 8, Grave C.

Comment (I.Š.): Expected age: 200–450 BP.

Z-2175. Slavonska Požega 6 270 ± 80

Human bones in soil from Trench 2, Grave 2f.

Comment (I.Š.): Expected age: maximum 700 BP.

Z-2176. Slavonska Požega 7 320 ± 60

Human bones from a stone-walled grave, Trench 4.

Comment (I.Š.): Expected age: 500 BP.

Z-2174. Slavonska Požega 8 370 ± 80

Wooden beam from the northern wall in the aisle.

Z-2170. Slavonska Požega 9 **690 ± 80**

Wooden beam from the eastern gable.

Comment (I.Š.): Expected age: 700 BP.

Z-2177. Slavonska Požega 10 **110 ± 80**

Human bones from Grave C.

Stari grad series

Fragments of charred wood from an ancient Greek settlement near Stari grad (43°10'N, 16°36'E), Hvar Island, Croatia. Collected and submitted 1989 by J. Jelčić, Institute for Preservation of Cultural Monuments, Split. Samples were dated to determine the time of destruction of this settlement.

Z-2178. Stari Grad 1 **2540 ± 70**

Fragments of charred wood from a Hellenistic house yard, 2 m depth.

Z-2183. Stari Grad 2 **1330 ± 80**

Fragments of charred wood in front of St. John's Early Christian Church.

Z-2181. Zadar **800 ± 80**

Wooden fragments covered with mortar from an arch in a crypt, Sv. Stošija Cathedral, Zadar (45°07'N, 15°15'E), south Croatia. Collected and submitted 1989 by M. Domijan, Institute for Preservation of Cultural Monuments, Zadar.

Comment (M.D.): Expected age: Middle Ages.

Nova Rača series

Human bones from Nova Rača church near Bjelovar (45°47'N, 16°56'E), 175 m asl, central Croatia. Collected and submitted 1989 by G. Jakovljević, Bjelovar Museum. Samples were dated to determine the chronology of the strata containing human bones.

Z-2184. Nova Rača **380 ± 60**

Bones buried in clay, 1.81 m below the church sacristy.

Z-2187. Nova Rača **610 ± 60**

Bones at 1.20 m below ground level from a necropolis outside the church, near the south wall.

Z-2255. Nova Rača **80 ± 80**

Bones from Grave 1 in the churchyard, 110 cm depth.

Z-2256. Nova Rača **70 ± 80**

Bones from Grave 2 in the churchyard, 87 cm depth.

Z-2258. Nova Rača 470 ± 70

Bones from plundered Grave 2, below the church sacristy, 100 cm depth.

Z-2260. Nova Rača 570 ± 80

Bones from plundered Grave 18, below the church sacristy, 30 cm depth.

Comments: (G.J.): Expected age: Middle Ages. (G.J.): Date confirms results of archaeological and historical investigations.

Grabovac series

Samples of charcoal from Eneolithic pits, from Grabovac brickyard near Đakovo (45°18'N, 18°27'E). Collected 1990 by I. Pavlović, Regional Museum Đakovo, and submitted by S. Forenbacher, Department of Archaeology, University of Zagreb.

Z-2239. 4760 ± 150

Charcoal from Pit 4.

Z-2240. 4250 ± 150

Charcoal from Pit 3B.

Comment (I.P.): Expected age: coeval with the Baden culture (Durman & Obelić 1989).

Vinkovci series

Charcoal from the floor of a primitive Vučedol-type house near Vinkovci (45°16'N, 18°49'E), ≈20 km west of Eneolithic site, Vučedol, east Croatia. Collected 1977 and submitted 1990 by A. Durman, Department of Archaeology, University of Zagreb. Samples were dated to determine the duration of the Vučedol culture in this area. Dates correspond to earlier measurements, Z-1817, -1818 (Srdoč *et al.* 1989: 87).

Z-2189. Vinkovci, Sample A 3940 ± 90

Charcoal.

Z-2190. Vinkovci, Sample B 4080 ± 130

Charcoal.

Z-2238. Krapina 1320 ± 140

Fragments of fossil oak from the Krapina River bed near Zaprešić (45°48'N, 15°58'E), Croatia. Collected 1989 and submitted 1990 by D. Stošić.

Z-1926. Koprivnički bregi 4470 ± 140

Charcoal mixed with soil from Pit DE/87 at Seče near Koprivnički bregi (46°10'N, 14°34'E), Koprivnica, Croatia. Collected and submitted 1987 by Z. Marković, Koprivnica Town Museum.

Comment (Z.M.): Expected age: 3000–4000 BC.

*HUNGARY***Gorzsa series**

Charcoal from tell-type Late Neolithic settlements from the Tisza region, southeast Hungary (Horvath, 1982, 1986, 1987; Benkő *et al.* 1989). Collected by F. Horvath, Mora Ferenc Museum, Szeged, and submitted 1987 by L. Benkő, Institute of Isotopes, Hungarian Academy of Sciences, Budapest.

Z-2007. Táapé – Lebö 1 **5870 ± 110**

Charcoal from Block I, Layer 2–3, Quadrant 4/A at Táapé – Lebö (46°16'N, 20°17'E), 82 m asl.

Z-2008. Szegvar – Tuszkoves 2 **6550 ± 160**

Charcoal from Block I, Layer 29, Quadrant 105 at Szegvar – Tuszkoves (46°36'53"N, 20°15'42"E), 87 m asl.

Z-2009. Gorzsa 3 **5610 ± 110**

Charcoal from Block XIV, Layer 6–7, Phase 6 at Gorzsa (46°16'25"N, 20°17'26"E), 81 m asl.

Z-2010. Gorzsa 4 **5820 ± 110**

Charcoal from Block VI, House 2, Phase C at Gorzsa.

Z-2011. Gorzsa 5 **5890 ± 110**

Charcoal from Block XVIII, Layers 24–25, Phase D at Gorzsa.

Comment (D.S.): Dates are discussed in Benkő *et al.* (1989).

HYDROGEOLOGICAL AND GROUNDWATER SAMPLES*YUGOSLAVIA***Ljubljansko barje series**

Groundwater from Ljubljansko barje peat bog (45°58'N, 14°32'E), Slovenia. Groundwater issues from a confined limestone aquifer. The total dissolved inorganic carbon (TDIC) consists predominantly of Ca-bicarbonate. Collected by J. Prestor and submitted 1988 by M. Veselič, Geological Institute, Ljubljana, Slovenia. This groundwater was studied in relation to a potable waterworks.

Z-2027. P-2 **21.1 ± 1.3 pMC**

Groundwater. Tritium activity: <0.2 Bq/liter.

Z-2028. Ž-4 **76.1 ± 1.4 pMC**

Groundwater. Tritium activity: 3.3 ± 0.2 Bq/liter.

Z-2029. V-3 **23.4 ± 1.1 pMC**

Groundwater. Tritium activity: <0.2 Bq/liter.

Bačka series

Samples were part of a hydrogeological and hydrodynamic study of groundwater from subartesian water-bearing horizons with intergranular porosity Bačka, Vojvodina. Collected and submitted 1988 by M. Lazarević, "Jaroslav Černi" Institute, Belgrade.

Z-2030. Savino Selo 1 **74.2 ± 1.1 pMC**

Groundwater from a phreatic well, 206.4 m deep, at Savino Selo (45°30'N, 19°33'E), 36.06–61.35 m depth (pH = 7.5, HCO₃ = 481 mg/liter).

Z-2031. Titov Vrbas 2 **7.0 ± 0.8 pMC**

Spring water supplying Titov Vrbas waterworks (45°34'N, 19°37'E), 121.60–144.70 m depth. Subartesian aquifer 156 m deep (pH = 7.7, HCO₃ = 518 mg/liter).

Z-2032. Kumra 3 **4.4 ± 0.8 pMC**

Groundwater from a subartesian well, 220 m deep, at Kumra, 185.00–198.50 m depth.

Z-2033. Zmajevo 4 **2.8 ± 0.8 pMC**

Artesian mineral water from a well, 369.80 m deep, at Zmajevo (45°27'N, 19°42'E), 348.90–367.90 m depth.

Z-2034. Bački Jarak 5 **1.9 ± 0.8 pMC**

Water from a subartesian well at Bački Jarak (45°22'N, 19°53'E), 158.16–181.50 m depth.

Z-2035. Bački Jarak 6 **6.4 ± 0.8 pMC**

Water from a subartesian well at Bački Jarak, 130 m deep, 90–123 m depth.

Surdulica series

Water, peat, soil and plants from Surdulica, one of the largest geothermal systems in southeast Yugoslavia, Mt. Besna kobilica massif, 1922 m asl, part of the geotectonic region of Serbia and Macedonia (Milovanović *et al.* 1989). The hydrogeothermal system is in the neogen-fissured granodiorite aquifer, surrounded by crystalline schists. The system produces cold water (~100 liter/s, alkalinity 61–140 mg/liter) and geothermal water (~70 liter/s, alkalinity 260–267 mg/liter). This series is part of an investigation of the mechanism of water formation in the Surdulica geothermal system. Collected and submitted 1988 by M. Hadžišehović, Institute Boris Kidrič, Belgrade.

Z-2066. Kula BK-6 **38.8 ± 1.3 pMC**

Water from a borehole, 112 m deep, at Kula near Kriva Feja (42°34'N, 22°09'E), 1354 m asl, Mt. Besna kobilica.

Z-2073. Bujanovac BH-7 1 **3.3 ± 0.8 pMC**

Geothermal water (43°C, pH = 6–6.5) from Borehole BH-7, 556 m deep, at Bujanovac (42°25'N, 21°45'E), 410 m asl, south Serbia. Collected 12–15 July 1988.

Z-2137. Bujanovac BH-7 2 **6.9 ± 0.8 pMC**

Groundwater from Borehole BH-7. Collected 20–25 May 1989.

Z-2074. Valjavica 22 **67.0 ± 1.1 pMC**

Water from the Valjavica well (13°C, pH = 5.5) near Surdulica (42°40'N, 22°10'E), 910 m asl, south Serbia.

Z-2135. Tolovački potok **61.3 ± 1.0 pMC**

Water from the Tolovac catchment near Vranjska Banja spa (42°30'N, 21°48'E), 577 m asl, Mt. Besna kobila.

Z-2136. Vranjska Banja V6-3 **4.8 ± 0.8 pMC**

Geothermal water (67°C) from a borehole, 450 m deep, at Vranjska Banja spa (42°30'N, 21°48'E), 406 m asl.

Z-2134. Ribarska Banja RB-5 **11.1 ± 0.9 pMC**

Geothermal water (40°–52°C) from Ribarska Banja spa (43°24'N, 21°31'E), 430 m asl, Mt. Jastrebac foothills.

Z-2138. Toplac **21.0 ± 0.9 pMC**

Geothermal water (20.5°–24°C) from Toplac (42°33'N, 21°57'E), 393 m asl.

Z-2067. Ladne Vode ML-1 **2.6 ± 0.8 pMC**

Water from a borehole, Mlava River valley near Gornjačka klisura (42°45'N, 20°25'E), southeast Serbia.

Z-2071. Ždrelo 11 **104.1 ± 1.2 pMC**

Water from a spring (pH = 6) at Ždrelo village near Petrovac (44°18'N, 21°32'E), 710 m asl, on the Mlava River.

Z-2072. Stari Glog 1 **94.1 ± 1.5 pMC**

Water (17.6°C, pH = 5.5–6) from a catchment at Stari Glog (42°28'N, 22°08'E), 710 m asl, Mt. Besna kobila.

Velenje series

Groundwater from several boreholes in brown coal (lignite) at Velenje coal mine (46°21'N, 15°07'E), Slovenia. Collected and submitted 1988 by M. Veselič, Geological Institute Ljubljana. This was part of an investigation of the origin of groundwater flooding the coal mine.

Z-2075. VAS-3 **2.2 ± 0.9 pMC**

Groundwater from Borehole VAS-3. Tritium activity: <0.2 Bq/liter. $\delta^{13}\text{C} = -5.2\text{‰}$

Z-2076. VAS-4	15.3 ± 1.4 pMC
Groundwater from Borehole VAS-4. Tritium activity: 0.6 ± 0.2 Bq/liter.	$\delta^{13}C = -7.9\text{‰}$
Z-2077. VAS-5	13.1 ± 1.1 pMC
Groundwater from Borehole VAS-5. Tritium activity: 0.6 ± 0.2 Bq/liter.	$\delta^{13}C = -8.6\text{‰}$
Z-2078. VL-16	0.0 ± 0.8 pMC
Groundwater from Borehole VAS-16. Tritium activity: <0.2 Bq/liter.	$\delta^{13}C = 0.6\text{‰}$
Z-2079. VAS-6	13.9 ± 1.0 pMC
Groundwater from Borehole VAS-6. Tritium activity: 0.5 ± 0.2 Bq/liter.	$\delta^{13}C = -8.6\text{‰}$
Z-2080. VAS-7	5.9 ± 1.3 pMC
Groundwater from Borehole VAS-7. Tritium activity: <0.2 Bq/liter.	$\delta^{13}C = -8.9\text{‰}$
Z-2081. VL-15	2.2 ± 0.8 pMC
Groundwater from Borehole VL-15. Tritium activity: <0.2 Bq/liter.	
Z-2082. VL-18	26.0 ± 1.0 pMC
Groundwater from Borehole VL-18. Tritium activity: 0.8 ± 0.2 Bq/liter.	$\delta^{13}C = -11.2\text{‰}$
Z-2083. VS-17	8.0 ± 0.8 pMC
Groundwater from Borehole VS-17. Tritium activity: <0.2 Bq/liter.	$\delta^{13}C = -19.1\text{‰}$
Z-2084. VS-19	6.7 ± 0.8 pMC
Groundwater from Borehole VS-19. Tritium activity: <0.2 Bq/liter.	$\delta^{13}C = -15.9\text{‰}$
Z-2085. VA-21	42.5 ± 1.1 pMC
Groundwater from Borehole VA-21. Tritium activity: 2.2 ± 0.2 Bq/liter.	$\delta^{13}C = -11.7\text{‰}$
Z-2086. VS-20	5.6 ± 0.8 pMC
Groundwater from Borehole VS-20. Tritium activity: <0.2 Bq/liter.	$\delta^{13}C = -18.2\text{‰}$
Z-2087. VA-22	30.3 ± 0.9 pMC
Groundwater from Borehole VA-22. Tritium activity: 1.0 ± 0.2 Bq/liter.	$\delta^{13}C = -11.8\text{‰}$
Z-2088. VS-23	30.8 ± 1.2 pMC
Groundwater. Tritium activity: <0.2 Bq/liter.	$\delta^{13}C = -13.6\text{‰}$

General Comment: Tritium activity in waters with relatively low ^{14}C activity indicates mixing of old and recent water, and the age of these waters cannot be determined on the basis of their ^{14}C content.

Niška Banja series

Thermomineral waters from Niška Banja spa (43°18'N, 22°01'E) near Niš, Serbia. Collected and submitted 1988 by M. Milivojević, Faculty of Mineralogy, Geology and Petrology Engineering, University of Belgrade. This was a hydrogeological investigation of the origin of thermomineral water in a low-temperature system of Niška Banja spa.

Z-2101. Glavno vrelo **49.7 ± 1.2 pMC**

Water from Glavno vrelo (main spring). Tritium activity: 0.7 ± 0.1 Bq/liter.

Z-2102. Suva Banja **51.2 ± 1.3 pMC**

Water from Suva Banja spa. Tritium activity: 0.7 ± 0.2 Bq/liter.

Z-2103. IEBNB-1 **14.6 ± 1.1 pMC**

Water from borehole IEBNB-1, 520 m depth, 210 m asl.

Z-2104. GC-3 **3.0 ± 0.8 pMC**

Mineral water from a 370-m-deep borehole, 150 m depth, 250 m asl, at Gornje Crniljevo near Osečina (19°40'N, 44°29'E), west Serbia. Water was dated in a hydrogeological investigation of the origin of the mineral water and the possibility of exploration. Tritium activity: <0.2 Bq/liter.

*CZECHOSLOVAKIA***Czechoslovakia series**

Groundwater samples from central Bohemian Karst and Mt. Male Karpaty, west Slovakia. Collected and submitted 1987 by N. Horvatinčić and J. Šilar, Faculty of Science, Charles University, Praha, Czechoslovakia. Dating of recent tufa helps determine the initial ^{14}C activity of groundwater.

Z-1972. Cisarska Rokle **78.7 ± 1.2 pMC**

Water from a spring at Cisarska Rokle, near Srbsko (49°52'N, 17°02'E), 310 m asl. Tritium activity: 4.7 Bq/liter.

Z-1973. Koda **87.1 ± 1.1 pMC**

Water from a catchment at Koda, near Srbsko (49°52'N, 17°02'E), 320 m asl. Tritium activity: 5.7 Bq/liter.

Z-1974. Babina **76.4 ± 1.1 pMC**

Water from a catchment at Babina, near Hradište pod Vratnom, Mt. Male Karpaty (48°33'N, 17°30'E). Tritium activity: 1.7 Bq/liter.

Z-1975. Sv. Jan pod Skalou **82.8 ± 1.1 pMC**

Water from a spring at Sv. Jan pod Skalou (49°53'N, 17°02'E). Tritium activity: 5.5 Bq/liter.

GEOLOGICAL SAMPLES

YUGOSLAVIA

Bačka series

Fossil soil was collected from boreholes in Bačka, Vojvodina for geotectonic investigations in northeast Serbia. Collected and submitted Sep. 1987 by M. Galečić, Geological Institute Belgrade.

Z-1952. Mali Beograd **33,800 \pm 3200
-2300**

Fossil soil from Borehole BT-39, E-71129 at Mali Beograd (45°53'N, 19°40'E), 107 m asl, 1030 cm depth.

Z-1953. Dušanovo **>37,000**

Fossil soil from Borehole BT-48, E-71129 at Dušanovo (45°54'N, 19°46'E), 95 m asl, 790 cm depth.

Z-1954. Gunaroš **26,700 \pm 2000**

Fossil soil from Borehole BT-53, E-71153 at Gunaroš (45°46' N, 19°50' N), 100 m asl, 960 cm depth.

Z-1955. Mileševo **29,900 \pm 2600**

Fossil soil from Borehole BT-54, E-71167 at Mileševo (45°44'N, 19°48'E), 104 m asl, 890 cm depth.

Z-1956. Mileševo

Fossil soil from Borehole BT-55, E-71162 at Mileševo (97 m asl), 915 cm depth.

Serbia series

Clay and peat were collected from Serbia in an investigation of the Quaternary of Serbia, and dated to draft a geological map of Yugoslavia. Collected and submitted 1987 by M. Rakić, Geozavod, Belgrade.

Z-1988. Radinac 079-4-2 4 **Modern
106.3 \pm 1.2 pMC**

Gray clay, 0.4 m below moor vegetation from an old bed of the Velika Morava River at Radinac, near Smederevo (44°39'N, 20°55'E), 72 m asl.

Z-1989. Zvečka 078-3-4 17 **7250 \pm 170**

Organogenic pond clay with fauna from an old meander of the Sava River at Zvečka village near Obrenovac (44°38'N, 20°10'E), 73 m asl, at depth 1.0–1.5 m below ground, covered by reeds and cultivated land.

Comment: Expected age: 4000–6000.

Z-1990. Zabrežje 078-3-2 35 **95.3 ± 1.2 pMC**

Aleurite with humus at Zabrežje village near Obrenovac (44°41'N, 20°05'E), 72 m asl, at depth 2.0 m, below cultivated land.

Comment: 680 ± 110.

Z-1991. Gaj 080-1-4 69 **11,220 ± 250**

Peat from an old meander of the Danube River at Gaj village, near Kovin (44°48'N, 21°02'E), 67 m asl, Banat, Vojvodina, at depth 1.0–1.5 m, below cultivated land.

Comment (M.R.): Expected age: 4000–6000.

Z-1992. Dubovac 080-1-4 70 **2750 ± 130**

Sandy peat from an old meander of the Danube River at Dubovac village (44°48'N, 21°10'E), 69 m asl, Banat, Vojvodina, from the surface.

Comment (M.R.): Expected age: 4000–6000.

Lake Bled series

Lake Bled (46°21'N, 14°08'E), 500 m asl. Collected and submitted 1988 by J. Pezdič, Institute Jožef Štefan, Ljubljana, as part of a sedimentological investigation of the origin of the lake marl. The lake marl consists of calcite without detrital minerals. $\delta^{13}\text{C}$ ranges between –1.03 and –2.36‰ vs. PDB.

Z-1993. B-K-2 **24.8 ± 0.9 pMC**

Lake sediment, 40 cm depth.

Z-1994. B-83 **75.4 ± 0.6 pMC**

Shells from the base of the lake, 2 m depth.

Z-1995. B-11/2 **23.6 ± 0.9 pMC**

Lake sediment, 0–10 cm depth.

Z-1996. B-11/2 **19.6 ± 0.8 pMC**

Lake sediment, 20–30 cm depth.

Z-1997. B-11/2 **26.2 ± 0.9 pMC**

Lake sediment, 50–60 cm depth.

Z-1998. B-11/5 **37.3 ± 0.9 pMC**

Lake sediment, 20–30 cm depth.

Z-1999. B-I-28 **17.3 ± 0.9 pMC**

Lake sediment, 5–20 cm depth.

Z-2001. B-I-28 **14.7 ± 0.8 pMC**

Lake sediment, 20–50 cm depth.

Z-1969. Selca **8820 ± 210**

Clay rich in organic material (humus), from a borehole core at 150 cm depth, from Selca, near Škofja Loka (45°13'10"N, 14°13'25"E), 430 m asl, Slovenia. Collected and submitted 1988 by A. Šercelj. Sample was dated for a vegetation profile.

Comment (A.Š.): Expected period: Holocene.

Kamniške Alpe series

Samples were dated in a lithostratigraphic investigation of alpine karst. Collected 1987 by J. Urbanc and submitted 1988 by J. Pezdič.

Z-2002. Kamniška jama cave **220 ± 80**

Humus from Kamniška jama cave (46°21'N, 14°31'E), 1100 m asl.

Z-2003. Ogrlice 2 **Modern**
105.2 ± 1.2 pMC

Topsoil at Ogrlice (46°20'N, 14°40'E), 0–15 cm depth.

Z-2004. Bela 3 **Modern**
103.9 ± 1.3 pMC

Topsoil at Bela (46°20'N, 14°37'E), 0–15 cm depth.

Z-2005. Ljubljansko barje **2800 ± 130**

Fragments of wood from Ljubljansko barje peat bog (45°59'N, 14°32'E). Collected by J. Urbanc and submitted 1988 by J. Pezdič, as part of a palynological investigation of Ljubljansko barje peat bog.

Surdulica series

This investigation was of ¹⁴C activity of peat, soil and plants in the recharge area of the Surdulica aquifer. Collected and submitted 1988 by M. Hadžišehović.

Z-2068. Lake Vlasina **Modern**
111.4 ± 1.5 pMC

Peat from Lake Vlasina shore (42°42'N, 22°20'E), 1300 m asl, southeast Serbia.

Comment (M.H.): Expected age: Holocene.

Z-2069. Lake Vlasina **Modern**
126.1 ± 1.4 pMC

Soil mixed with grass from a clearing near Lake Vlasina (42°42'N, 22°20'E) 1295–1300 m asl, Mt. Besna kobila.

Z-2070. Lake Vlasina**Modern**
123.9 ± 1.5 pMC

Various unidentified plants from the Lake Vlasina area.

Comment: Result is close to the atmospheric ^{14}C activity.**Z-2089. Unije Island 51-4-J****5700 ± 150**

Loess concretions (loess kindchen) from Unije Island (44°35'N, 14°18'E), 9 m asl, Adriatic Sea, Croatia. Collected for a stratigraphic and sedimentologic investigation. Collected and submitted 1988 by Z. Velimirović, INA-Project, Zagreb.

Z-2097. Sesalac cave**64.4 ± 1.1 pMC**

Speleothem deposited on a wall of the main shaft of a short tunnel, Sesalac cave near Soko Banja (43°41'53"N, 21°59'26"E), 602 m asl, Serbia. Sample was dated to determine the time of gravel filling (Petrović 1984). Collected and submitted 1987 by D. Gavrilović, Faculty of Natural Sciences and Mathematics, Belgrade.

Comments (D.G.): Expected age: Pleistocene. (D.S.): assuming $A_0 = 100$ pMC, the speleothem ^{14}C age is 3500 ± 140 BP.**Rijeka series**

Organic fraction from Boreholes A-2 and S-2 at Rijeka (45°18'N, 14°25'E), southwest Croatia. Collected and submitted 1987 and 1989 by E. Pavlovec, Institute for Civil Engineering, Rijeka. Collected for geotechnical investigations of the city development area.

Z-2036. Rijeka**6410 ± 160**

Organic mud from Borehole A-2, 8 m depth.

Z-2105. 1**3680 ± 140**

Organic fraction of soil, 25 m depth.

Z-2106. 2**1330 ± 120**

Organic fraction of soil, 5.7 m depth.

Comment: Expected age: Holocene.**Lake Kozjak series**

Samples of calcareous lake sediment from the Plitvice Lakes (44°50'N, 15°35'E) central Croatia were collected with a hand corer February 1989 by scuba diver, D. Petricoli, Center for Marine Research, Rudjer Bošković Institute, Zagreb.

TABLE 1. Lake Kozjak Sediment Core

Sample no.	Depth (cm)	pMC	Age (BP)	$\delta^{13}\text{C}_{\text{‰}}$ (PDB)
Z-2116	5–10	79.9 ± 0.6	Modern	–8.6
Z-2117	10–15	74.0 ± 0.6	214 ± 70	–8.9
Z-2118	15–20	74.4 ± 0.6	170 ± 70	–9.1
Z-2119	20–25	73.6 ± 0.8	260 ± 90	–9.2
Z-2120	25–29	73.3 ± 0.8	290 ± 90	–9.1

Z-2127. Lake Kozjak **82.1 ± 1.0 pMC**

The organic part of the sediment was used to date the organic residue after chemical pretreatment of samples Z-2117, -2119 and -2120.

Comment: Initial ^{14}C activity, $A_0 = 76\%$, was determined by two independent methods (Srdoč *et al.* 1986b; Krajcar Bronić *et al.* 1992). Table 1 shows the results.

Plitvice travertines series

Travertine from the Plitvice Lakes (44°50'N, 15°35'E) central Croatia. Collected and submitted 1989 by H. Chafetz, Department of Geosciences, University of Houston, D. Srdoč and N. Horvatinčić.

Z-2142. Plitvički Ljeskovac **0.0 ± 0.5 pMC**

Compact crystalline flowstone from old travertine barrier near Plitvički Ljeskovac.

Z-2143. Smolčića cave **1.7 ± 0.5 pMC**

Compact, hard, partly porous travertine above Smolčića cave.

Z-2144. Bijela rijeka **1.4 ± 0.6 pMC**

Crystalline flowstone from an inactive travertine barrier above Bijela rijeka brook.

General Comment (D.S.): Samples were collected for U/Th analysis. The ^{14}C content indicates the degree of contamination with recent carbonates.

Z-2124. Rovinj **9270 ± 250**

Peat from a borehole in marine sediment, 98–108 cm depth, at station 109 in the North Adriatic Sea near Rovinj (45°05'N, 13°37'E). Collected and submitted 1989 by S. Puškarić, Center for Marine Research, Rudjer Bošković Institute, Zagreb.

Krka River series

Tufa from Krka River near Skradin (43°49'N, 15°55'E), Croatia. Collected and submitted 1989 by D. Srdoč, N. Horvatinčić, S. Golubić, Boston University and A. Plenković, University of Zagreb, and 1991 by D. Srdoč and T. Bjedov, Elektroprojekt, Zagreb.

Z-2253. 1 **76.1 ± 0.8 pMC**

Recent tufa near Roški slap waterfall.

Z-2254. 2 **79.7 ± 0.8 pMC**

Recent tufa near Roški slap waterfall, downstream from Z-2253.

Z-2264. 3 **81.7 ± 0.8 pMC**

Recent tufa, Lake Mlinarsko.

Z-2141. 4 **83.1 ± 0.8 pMC**

Recent tufa from a barrier, surface layer, downstream from Lake Mlinarsko.

Z-2139. 5 **93.0 ± 0.8 pMC**

Recent tufa, Skradinski buk waterfall.

Z-2262. 6 **95.8 ± 0.8 pMC**

Recent tufa, Skradinski buk waterfall.

Z-2140. 7 **95.9 ± 0.8 pMC**

Recent tufa, Skradinski buk waterfall.

Comment (D.S.): Measurements were of recent tufa activity in the Krka River, north Dalmatia, Croatia. ^{14}C activity of dissolved inorganic carbon (DIC) increases downstream due to the exchange with more active atmospheric CO_2 (Srdoč *et al.* 1986a). Recent tufa precipitated from DIC reflects the DIC ^{14}C activity. We observed an increase of 10% in ^{14}C activity over a 12-km-long stretch between locations, Roški slap and Skradinski buk.

Z-2251. Kalića kuk 1 **1.7 ± 0.8 pMC**

Old tufa barrier, presently 10–15 m above the lake surface. Hard, compact tufa from the top of the barrier.

Z-2252. Kalića kuk 2 **3.0 ± 0.8 pMC**

Hard, very porous tufa from the top of the barrier.

Z-2250. Kalića kuk 3 **2.5 ± 0.8 pMC**

Hard, porous tufa from a niche dug in the barrier, ~2 m above the lake surface.

Comment (D.S.): ^{14}C activity of old, preglacial tufa reflects the contamination with recent carbonates, not the age of the samples.

Z-2323. Manojlovac waterfall **75.8 ± 0.8 pMC**

Tufa crust on limestone.

Z-2324. Manojlovac water mill **75.7 ± 0.8 pMC**

Tufa crust on wood.

Comment (D.S.): Samples Z-2323 and -2324 were collected in a dry riverbed. This section of the Krka River was diverted in 1908 into a hydroelectric power plant; hence, the samples reflect pre-bomb ^{14}C activity.

Varaždinske Toplice series

Tufa from the thermal Varaždinske Toplice spa (46°10'N, 16°25'E), Croatia. Collected and submitted 1989 by D. Srdoč, N. Horvatinčić and H. Chafetz.

Z-2147. 1 **0.7 ± 0.8 pMC**

Calcareous deposit on cooling tower walls.

$\delta^{13}\text{C} = 0.4\text{‰}$

Z-2149. 2 **2.9 ± 0.5 pMC**
 Tufa from the bottom of Gradišće cave. $\delta^{13}C = -1.1\text{‰}$

Z-2155. 3 **0.5 ± 0.6 pMC**
 Recent tufa from a spring. $\delta^{13}C = 0.8\text{‰}$

Z-2157. 4 **0.0 pMC**
 Tufa from an old barrier near Sv. Duh chapel. $\delta^{13}C = -2.1\text{‰}$

Z-2158. 5 **5.3 ± 0.4 pMC**
 Tufa deposit covering Roman ruins. $\delta^{13}C = 0.7\text{‰}$

Comment (D.S.): $\delta^{13}C$ values indicate a non-biogenic origin of the tufa. ^{14}C activity is due to contamination with recent carbonates.

Z-2148. 076-4-2(49-1) **5730 ± 110**
 Alluvial-proluvial sediment southwest of Šabac (44°47'N, 19°39'E), Serbia, collected and submitted 1989 by M. Rakić, Geological Institute, Belgrade, for drafting a geological map of Yugoslavia.

Baška series

Charcoal fragments in clayey sandy gravel near Baška (44°59'N, 14°45'E), Krk Island, Croatia. Collected and submitted 1989 by L. Marjanac, INA Project, Zagreb.

Comment: Expected age: Middle Pleistocene. Samples were dated to interpret paleofacies.

Z-2150. Baška 1-XXV-6-1 **5130 ± 300**
 Organic soil, 8 m asl.

Z-2151. Baška 3-XXIV-6-1 **25,610 ± 2640**
 Organic soil, 8 m asl.

Z-2153. Baška 117/2-6 **24,790 ± 790**
 Organic soil, 10 m asl.

Z-2152. Karojba **98.3 ± 0.9 pMC**
 Fragment of driftwood near Karojba (45°18'N, 13°49'E), Istria, west Croatia. Collected 1989 by S. Puškarić and submitted by M. Mihovilović, Istarski boksiti, Rovinj.

Z-2166. Krupa River **45.3 ± 0.7 pMC**
 Tufa covering the bed of the Krupa River (44°11'N, 15°54'E), Bukovica, south Croatia. Collected and submitted 1989 by D. Srdoč, N. Horvatinčić and H. Chafetz.

Z-2167. Krčić **56.0 ± 0.7 pMC**
 Tufa from Krčić brook waterfall, downstream from Krčić village (44°01'N, 16°18'E) near Knin,

south Croatia. Collected and submitted by D. Srdoč and H. Chafetz.

Z-2180. Pag 5-VI-7-K **>37,000**

Organic soil from Pag Island (44°26'N, 15°04'E). Collected and submitted 1989 by L. Marjanac.

UNITED STATES

Z-2191. White Bluff **91.6 ± 0.8 pMC**

Recent tufa from White Bluff, Texas. Collected and submitted 1990 by H. Chafetz.

Comment: Sample was dated to determine the initial ¹⁴C activity.

CZECHOSLOVAKIA

Czechoslovakia series

Tufa samples from central Bohemian Karst and Mt. Male Karpaty, west Slovakia were dated to determine initial ¹⁴C activity. Collected and submitted 1987 by N. Horvatinčić and J. Šilar.

Z-2115. Koda **99.6 ± 1.2 pMC**

Recent tufa covered by aquatic moss (*Cratoneurum commutatum*) from Koda valley near Srbsko (49°50'N, 14°15'E), 320 m asl.

Z-1979. Koda **91.9 ± 1.3 pMC**

Recent tufa, 300 m downstream, at Koda near Srbsko.

$$\delta^{13}C = -9.0 \pm 0.4\text{‰}$$

Z-1976. Cisarska Rokle **81.8 ± 1.2 pMC**

$$\delta^{13}C = -9.3 \pm 0.4\text{‰}$$

Recent tufa, 150 m downstream from a lower eroded cascade at Cisarska Rokle (49°52'N, 17°02'E).

Z-1977. Cisarska Rokle **89.2 ± 1.2 pMC**

$$\delta^{13}C = -7.1 \pm 0.4\text{‰}$$

Recent tufa, 300 m downstream from a lower eroded cascade at Cisarska Rokle.

Z-1978. Cisarska Rokle **46.1 ± 0.9 pMC**

Tufa from a lower eroded cascade, on a bank near the waterfall.

Z-1980. Hradište pod Vratnom **0.1 ± 0.6 pMC**

Old tufa from a quarry at Hradište pod Vratnom, Mt. Male Karpaty (49°00'N, 17°25'E).

Z-1981. Sv. Jan pod Skalou 8 **46.1 ± 0.9 pMC**

Dark gray tufa from Sv. Jan pod Skalou (49°53'N, 17°02'E).

Z-1982. Sv. Jan pod Skalou 9 **57.0 ± 1.0 pMC**

Yellowish porous tufa.

Z-1983. Sv. Jan pod Skalou 10
52.2 ± 0.9 pMC

Porous tufa with clay particles.

Z-1984. Sv. Jan pod Skalou 11
51.9 ± 0.9 pMC

Yellowish porous tufa, 30 cm above Sample 10.

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