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THE RADIOCARBON DATA BASE AT RUDJER BOŠKOVIĆ INSTITUTE RADIOCARBON LABORATORY

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ABSTRACT. A multidisciplinary radiocarbon data base system written in dBASE III PLUS which follows the recommendations of the International Database Commission and specific requirements of our laboratory is described. The system updates, stores and maintains records and retrieves data according to specific key-words.

INTRODUCTION

The need for computer processing and data entry into a data base was realized very soon after starting the Rudjer Bošković Institute Radiocarbon Laboratory in the early 1970s. These systems were established on a UNIVAC 1110 computer located at the University Computing Center, and later transferred to an HP-1000 located at the Institute. Our data base contains basic data on samples and results measured at our laboratory, including comprehensive karst studies phenomena, in which several hundreds of isotopic data obtained on calcite deposits, water and various biological samples have been analyzed (Srdoč *et al*, 1980, 1985, 1986). We can also prepare date lists for publication in *RADIOCARBON* from our data base.

The recent aquisition of an IBM-compatible PC, sponsored by the IAEA in 1987, enabled us to design a sophisticated multidisciplinary data base, which is exclusive to our laboratory. Creation and updating of data stored at Rudjer Bošković Radiocarbon Data Base include entering all relevant data on submitted samples, sample pretreatment and preparation and measurement in the proportional counter. Data retrieval from samples of various series, archaeologic or geologic periods, age intervals, regions, etc, is possible by selecting desired key-words. Records can be displayed on the screen, printed out for mailing or transferred to another database form for exchange with other laboratories.

The computer system consists of an EMD PC-1021 (IBM AT-compatible) with Hercules monochrome card, 640 kbytes of RAM and 20 MBy hard disk. A backup copy of the contents of the hard disk can be made on a magnetic tape, and separate files or entire directories are copied onto floppy diskettes. We use the DOS operating system, version 3.21, Microsoft Fortran 77 and dBASE III PLUS, version 1.1.

DATABASE FILES

Data are entered into a menu-accessed dBASE III PLUS program and stored on four database files (DBF) and corresponding database memo files (DBT) for comments which occupy an unlimited number of characters, as follows:

C14S.DBF – Data on submitted samples and final results of measurement

C14P.DBF – Data on sample pretreatment

C14M.DBF – Data on measurement in the proportional counter

C14B.DBF – Data on inactive and active standards

Data bases 1, 2 and 3 are linked together with our lab code designation, Z. C14S.DBF is the only database file important for users and for exchanging data. It consists of 39 fields (296 bytes) which follow those recommended by the International Database Commission (Kra, 1986) (Fig 1). Each sample is identified by a separate record. Descriptions in each record are entered as characters, but a relatively large part of the infor-

Field	Field name	Type	Width	Description
1	LAB–NO	Numeric	5	Laboratory number (Z-...)
2	LAB–CODE	Character	1	Sample material code (fig. 2)
3	SERIES	Character	12	Series
4	DISCIPLINE	Character	5	Scientific discipline (fig. 4)
5	SAMPLE–MAT	Character	15	Sample material description
6	SITE–TYPE	Character	45	Description of site
7	SAMPLE–NO	Numeric	4	Sample number within a series
8	SITENAME	Character	15	Name of the narest site
9	STATE	Character	10	Federal state or province
10	COUNTRY	Character	10	Country
11	LAT–DEG	Numeric	2	Geographic latitude (DD°MM′SS″)
12	LAT–MIN	Numeric	2	″
13	LAT–SEC	Numeric	2	″
14	GEOG–LAT	Character	1	″ (N,S)
15	LONG–DEG	Numeric	2	Geographic longitude (DD°MM′SS″)
16	LONG–MIN	Numeric	2	″
17	LONG–SEC	Numeric	2	″
18	GEOG–LONG	Character	1	″ (E,W)
19	HEIGHT–ASL	Numeric	5	Height above sea level (m)
20	STRAT	Numeric	5	Stratigraphic data (cm,m)
21	COLL–BY	Character	15	Collector's name
22	COLL–DATE	Date	8	Date of collection
23	COLL–INST	Character	10	Code of collector's institution
24	SUBM–BY	Character	15	Submitter's name
25	SUBM–DATE	Date	8	Date of submission
26	SUBM–INST	Character	10	code of submitter's institution
27	CULT–PD	Character	3	Culture – archaeol or geol period code
28	EXP–AGE	Numeric	5	Expected age (years BP)
29	C13	Numeric	6,2	$\delta^{13}C$ value
30	C–C13	Numeric	4,2	$\delta^{13}C$ error
31	INIT–ACT	Numeric	5	Initial activity (in %)
32	MEASURED	Numeric	3	Number of measurements
33	PM–KON	Numeric	6,2	Result in percent modern
34	SPM–KON	Numeric	4,2	Error of percent modern
35	AGE–KON	Numeric	6	Age (BP)
36	AGES–KON	Numeric	4	Age error (BP)
37	RANGE–KON	Character	15	Calibrated range (AD, BC)
38	RADIOCARB	Numeric	2	Rudjer Bošković Institute RADIOCARBON date list No.
39	SUB–COMM	Memo	10	Collector's and/or submitter's comment (unlimited length)

Fig 1. Structure of database C14S.DBF

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mation is in numeric form. Numeric data entered as characters can occupy a different position in the required character field, enabling correct retrieval and sorting of records. Although the data base proposed by the International Database Commission consists of character fields only, the transformation of our data base is easily possible by using the dBASE III PLUS software program.

C14P.DBF consists in data on pretreatment and preparation of samples for measurement in the proportional counter. All samples are first burned to CO_2 (carbonate samples are converted to CO_2 by reaction with acid). After purification, CO_2 is converted to methane which we use as the counting gas. Creating a separate record for each preparation allows for the possibility of different or repeated preparations. With this database file, we can follow the "history" of various preparation devices to find possible sources of contamination (memory effect).

C14M.DBF consists in data on measurement in the proportional counter, as well as some meteorological data. A separate record is created for each measurement. After calculation, results of every measurement are also stored in this database file.

C14B.DBF consists in records of inactive and active standards, as measured in consecutive periods. The program automatically retrieves those values of standards which correspond to each measurement.

CALCULATION

To use the data bases, as well as to calculate results of measurements, a desired operation is chosen from the main menu (Fig 2). Operation "A" activates a software chain of data including updating (C14S.DBF), sample preparation (C14P.DBF) and measurement (C14M.DBF). Each measurement in the proportional counter takes ca 24 hr and the count rate, divided into 20 min intervals, is printed out. After entering the main data on the measurement into File C14M.DBF, the program calls a FORTRAN

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                    14C Database and Processing of Data

                           C A L C U L A T I O N
A - Input/updating of all data about samples and calculation of ages

        UPDATING OF DATA                         LISTING OF DATA
B - Data on samples (C14S.DBF)          J - Extended report on individual
C - Data on preparation (C14P.DBF)          samples
D - Data on Standards (C14B.DBF)        K - Listing of data on samples
E - Submitter's comment (C14S.DBT)          according to various keywords
F - Comment on preparat. (C14P.DBT)     L - Chronological listing of data
G - Comment on measuremt.(C14M.DBT)         about measurement in counter
H - Final comment (C14S.DBT)            M - Listing of FINAL results (mean)
I - Final results enter to C14S.DBF         according to various keywords

               Enter Selection (A - L, or X to quit)
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Fig 2. Main menu

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program for data processing, statistical processing and calculating of results. This is a revised version of the program described by Obelić & Planinić (1977). Results are again stored in C14M.DBF and printed out for check-up. After the last measurement of a sample, a final report can be created and the averaged values of results can be stored in C14S.DBF. All finalized results are calibrated according to a simplified version of the program designed at the University of Washington (Stuiver & Reimer, 1986). Statistical processing of data is written in FORTRAN, while all other steps are written in dBASE III PLUS. $\delta^{13}C$ correction can be made for each sample individually. However, if $\delta^{13}C$ data do not exist, age correction due to isotopic fractionation is made for various sample materials according to suggestions of Stuiver and Polach (1977).

DATA RETRIEVAL

One of the main tasks of a database program is retrieval of records of particular interest. By calling the dBASE III PLUS routine, SEEK, searching for single records indexed on laboratory numbers takes only several seconds. By selecting the appropriate operation at the main menu, we can add new or update existing records. We can retrieve particular records or groups of records by entering specific key-words or key-codes into the command, FILTER, which displays records of a database file that meet a specific condition, as shown in Figure 3. Key-words can be related to

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Samples of arch./geol. period "Eneolithic"

Lab.№	Series code	Sample material Code Description	Site description	Site name	State/ province	Cult. period	$\delta^{13}C$ (‰)	% mod.	^{14}C age (BP)	Calib.interv. (Stuiver,Reimer)	R. №
Z-278	BARJE-MAHAR	D Wood fragments	Pile dwellings, peat bog, drainage Veliki Mah	Ljubljana	Slovenia	ENE		51.1	4633 ± 117	BC 3612-3140 BC	3
Z-355	BARJE-MAHAR	6 Organic soil	Pile dwellings, peat bog, drainage Veliki Mah	Ljubljana	Slovenia	ENE		55.9	4645 ± 58	BC 3506-3352 BC	
Z-539	BARJE-PARTI	D Wood fragments	Pile dwellings, peat bog at Parti	Ljubljana	Slovenia	ENE		61.2	3917 ± 53	BC 2484-2345 BC	5
Z-982	BARJE-PARTI	D Wood fragments	Pile dwellings, lake chalk, peat bog at Parti	Ljubljana	Slovenia	ENE		59.0	4208 ± 79	BC 2913-2629 BC	8
Z-722	KOPR.RIJEKA	U Charcoal	Waste pit, Rudina (late Vučedol culture)	Koprivnica	Croatia	ENE		62.1	3750 ± 77	BC 2296-2039 BC	6
Z-1474	MOVERNA VAS	U Charcoal	Fire-place, Moverna Vas, layer 7 (2.2-2.5 m)	Črnomelj	Slovenia	ENE		50.9	5396 ± 131	BC 4359-4041 BC	10
Z-1475	MOVERNA VAS	U Charcoal	Fire-place, Moverna Vas, layer 6 (1.5-1.8 m)	Črnomelj	Slovenia	ENE		54.0	4917 ± 125	BC 3930-3539 BC	10
Z-1685	MOVERNA VAS	U Charcoal	Fire-place, Moverna Vas, layer 5 (1.5-1.8 m)	Črnomelj	Slovenia	ENE		61.4	3886 ± 95	BC 2554-2205 BC	10
Z-409	ODMUT	U Charcoal	Rock shelter Odmut, block 5, layer III	Piva r	Montenegro	ENE		58.5	4288 ± 120	BC 3036-2703 BC	4
Z-1618	VUCEDOL-BAD	U Charcoal	Vučedol, Q-131/164, pit 88 (Baden culture)	Vukovar	Croatia	ENE		58.2	4310 ± 100	BC 3037-2784 BC	10
Z-1619	VUCEDOL-BAD	U Charcoal	Vučedol, Q-86/87, pit 21 (Baden culture)	Vukovar	Croatia	ENE		57.6	4400 ± 100	BC 3307-2914 BC	10
Z-1864	VUCEDOL-BAD	K Bone	Vučedol, pit 2 (Baden culture)	Vukovar	Croatia	ENE		56.0	4626 ± 100	BC 3592-3145 BC	11
Z-1820	VUCEDOL-KOST	U Charcoal	Vučedol, pit V-85-32 (Kostolac culture)	Vukovar	Croatia	ENE		57.7	4374 ± 95	BC 3263-2911 BC	11
Z-1821	VUCEDOL-KOST	U Charcoal	Vučedol, pit V-84-103 (Kostolac culture)	Vukovar	Croatia	ENE		56.8	4502 ± 101	BC 3361-3034 BC	11
Z-1449	VUCEDOL-VUC	U Charcoal	Vučedol, Q-107/138, grave 2 (Vučedol culture)	Vukovar	Croatia	ENE		59.1	4195 ± 82	BC 2911-2623 BC	10
Z-1624	VUCEDOL-VUC	U Charcoal	Vučedol, Q-33/43, pit 19 (Vučedol culture)	Vukovar	Croatia	ENE		58.9	4200 ± 100	BC 2915-2618 BC	10
Z-1637	VUCEDOL-VUC	U Charcoal	Vučedol, Q-36, pit 6, bottom (Vučedol cult.)	Vukovar	Croatia	ENE		58.1	4300 ± 100	BC 3034-2709 BC	10
Z-1863	VUCEDOL-VUC	K Bone	Vučedol, pit 13 (Vučedol culture)	Vukovar	Croatia	ENE		59.1	4190 ± 122	BC 2917-2590 BC	11

Total printed №: 18

Fig 3. Listing of final results for some samples of culture period denoted by ENE (Eneolithic). Last column (R No.) denotes number of Rudjer Bošković Institute *RADIOCARBON* date list where data about the sample were published.

specific research fields, sample material codes, age interval, countries and regions, collectors and submitters and serial codes which allows for easy retrieval of all relevant data (Fig 4).

Disciplines (fields)

ARCH – Archaeology
BIOL – Biology
ENV – Environmental sciences
GEOL – Geology
HYDRO – Hydrology
STAND – Samples of standard

Sample material

A	– Anthracite (background)	B	– Marble (background)
C	– Atmospheric CO_2	D	– Wood, wooden cellulose
E	– Borehole gas	F	– Recent plants (C–3 cycle)
G	– Organic soil	H	– C-4 plants
I	– Leaves, annual plants	J	– Bone apatite
K	– Bone collagen	L	– Soil carbonate, loess
M	– Marine organisms	N	– Terrestrial molluscs
O	– Oxalic acid standard	P	– Peat
Q	– Lake carbonate	R	– Marine carbonate
S	– Speleothems	T	– Tufa, travertine
U	– Fossil wood, charcoal	V	– Freshwater, groundwater
W	– Freshwater submerged plants	X	– Experimental samples
Y	– Various	Z	– Mortar

Archaeological and geological periods

Archaeology	Geology
PALaeolithic	PLEistocene
MESolithic	HOLocene
NEOlithic	
ENEolithic	
BROnze age	
IROn age	
EAStern cultures	
ANTique period	
MIDdle ages	
NEW age	
MODern sample	

Fig 4. List of key-words used in the data base

COMMENTS AND CONCLUSION

We tested our data base on a set of data that contained more than 2500 records. We are convinced that the transformation to other data bases should not cause any problems, and requires only a relatively simple software, because dBASE III PLUS facilitates copying other database structures of the same type or similar types to SDF (System Data Format ASCII), DIF (VisiCalc), SYLK (Multiplan), WKS (Lotus 1–2–3) or others.

Probably the most difficult problem would come from using key-word or key-code systems that are developed independently by other laboratories. Key-words that denote sample materials, regions (countries), archaeologic or geologic periods and other data relevant to each sample have to be standardized. This is of particular importance for archaeologic and/or geologic periods. Some laboratories use designations for more extended periods (eg, Holocene in geology or Paleolithic in archaeology), while others denote more specific periods (Boreal, Atlanticum, ...or Gravettian, Aurignacian, etc). Different names may be used for the same periods (Eneolithic *vs* Chalcolithic, Younger Holocene *vs* Lower Holocene). The International Radiocarbon Database Commission should design a list of key-words acceptable to all laboratories and users.

More than 2500 samples related to archaeology, geology and other fields have been measured at our laboratory since 1970. By creating a data base, we hope to simplify reporting radiocarbon results to our submitters, to prepare date lists for publication in *RADIOCARBON*, and to transmit radiocarbon results on floppy diskettes to the proposed International Radiocarbon Data Base (IRDB). Our main problem for simultaneous use of the data base for reporting data to submitters and later publication in *RADIOCARBON* or in the international exchange, is language. Specific data about samples and especially comments cannot be written in our language and English at the same time.

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