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PENGUIN, A MACINTOSH APPLICATION FOR ENTRY AND PRESENTATION OF RADIOCARBON-DATED SAMPLES

ANTONIO PETRI[1] *and CARLO BARONI*

Dipartimento di Scienze della Terra, Università di Pisa and C.N.R. - Centro di Studio per la Geologia Strutturale e Dinamica dell'Appennino, Via S. Maria 53, I-56126 Pisa, Italy

ABSTRACT. *Penguin* is a Macintosh computer application that facilitates the use of CALIB 3.03, the ^{14}C age calibration program by Stuiver and Reimer (1993). Penguin offers an easy user interface based on the well-known Macintosh standard multiwindow environment to create and edit the CALIB 3.03 calibration files and to export data in text format. *Penguin* and CALIB interact at the file level, *i.e.*, *Penguin* is capable of reading and writing files in CALIB formats. Files containing the data are created in the *Penguin* environment and then saved on disk in the *Penguin* format. *Penguin* allows multiple editing of the calibration parameters and recalibration of the list of samples without the need to insert any modifications manually throughout the list. *Penguin* can also be used to read already calibrated files in order to extract the "cal" ages and display them in a spreadsheet-like window.

INTRODUCTION

Penguin is a Macintosh computer application that facilitates the use of CALIB 3.03, the well-known ^{14}C age calibration program by Stuiver and Reimer (1993).[2] The "*Penguin* project" emerged from our need for flexibility in managing data sets of ^{14}C-dated samples (The name was suggested by the prettiest subject we were dealing with). In particular, we frequently need to update and calibrate sets of ^{14}C dates from marine organisms (Baroni and Orombelli 1991) or from organisms that lived or fed in the sea, such as penguins and seals (Baroni *et al.* 1991; Baroni 1994; Baroni and Orombelli 1994). Nevertheless, the program is also useful for managing and editing sets of calibrated dates of other origin.

Penguin is at an early stage of development and is currently used at the Earth Science Department of the University of Pisa (Italy). Its currently implemented capabilities reflect the needs of the researchers who deal with ^{14}C dates. Features are added or modified each time a new need arises from our work. This means that the look and the functionality of *Penguin* may change in future releases, particularly if users assist us by supplying observations and suggestions for adding capabilities and/or modifying existing ones. Furthermore, some tools for graphical processing are currently being studied and could be added shortly.

Penguin is free software and is available from glsun2.gl.rhbnc.ac.uk via anonymous FTP, in the directory /pub/mac/apps.

PENGUIN CALIBRATION UTILITIES

As is well known, the ^{14}C dates from remains of organisms that lived or fed in the sea are affected by an offset known as the "reservoir effect", induced by the depletion of ^{14}C in the ocean. This depletion is related to regional variations in oceanic and atmospheric circulation and its magnitude has also varied through time (Broecker and Olson 1961; Broecker, Peng and Engh 1980; Östlund and Stuiver 1980; Stuiver and Östlund 1980; Gordon and Harkness 1992). In the Antarctic Ocean, the reservoir effect is particularly elevated, owing to the dilution of circumantarctic water with glacial meltwater and by the upwelling of deep and old oceanic water (Harkness 1979; Omoto 1983;

[1]*Present address:* Department of Geology, Royal Holloway University of London, Egham, Surrey TW20 0EX, United Kingdom
[2]The current version of CALIB is available at http://weber.u.washington.edu/~qil/calib.html.

Stuiver, Pearson and Braziunas 1986). Thus, the apparent ages yielded by Antarctic samples are anomalously old as a consequence of the very low level of ^{14}C concentration in Antarctic water; the error is estimated to be >1000 yr and varies with different organisms and materials (Harkness 1979; Omoto 1983; Stuiver *et al.* 1981; Stuiver, Pearson and Braziunas 1986; Whitehouse, Chinn and Höfle 1988, 1989; Björck *et al.* 1991; Gordon and Harkness 1992; Berkman and Forman 1996). In order to compare the ^{14}C dates obtained from Antarctic samples with ^{14}C ages derived elsewhere, the ^{14}C ages need to be corrected for the reservoir effect and calibrated as accurately as possible.

According to Stuiver, Pearson and Braziunas (1986) and Stuiver and Reimer (1993), the calibration procedure for marine-derived organisms requires the computation of a parameter, ΔR, that is the constant difference in reservoir age of a regional part of the ocean and the world ocean. ΔR values can be determined if samples of known historical age are available (actually, only samples from organisms that died before the era of nuclear tests are suitable for this purpose). Such samples mainly derive from penguins and seals killed at the beginning of the century during the historical Antarctic expeditions (Stuiver *et al.* 1981; Mabin 1985, 1986; Orombelli 1988; Whitehouse, Chinn and Höfle 1988, 1989; Björk *et al.* 1991). Recently, dates from shells of known age have been supplied as well (Berkman and Forman 1996).

Table 1 lists ^{14}C dates of known-age samples; it can be observed that the conventional ages span a wide time interval. Therefore, in order to perform the best possible calibration, different ΔR values should be applied to different sets of ^{14}C dates obtained from different organisms. Namely, ^{14}C dates from penguin remains should be calibrated using a ΔR value derived only from penguin samples of known age ($\Delta R = 688 \pm 55$ is the weighted mean of seven values from penguin remains; $\Delta R = 656 \pm 55$ is the weighted mean of three values from Adélie penguin remains only).

TABLE 1. Radiocarbon Dates from Samples of Known Age from Antarctica

Sample no.	Location	Material	Historical age (AD)	Conv. age (^{14}C yr BP)	ΔR (^{14}C yr BP)	Reference
Lu31101	Hope Bay	Penguin bones	1903	1280 ± 50	816 ± 50	Bjork *et al.* 1991
4432	Cape Royds	Adélie penguin flesh	1904	925 ± 75	462 ± 75	Geyh and Wirth in Whitehouse, Chinn and Hofle 1988
4433	Cape Adare	Flesh mew of prey	1902	1125 ± 90	660 ± 90	Geyh and Wirth in Whitehouse *et al.* 1988
QL173	Inexpressible Is.	Emperor penguin	1912	1300 ± 50	838 ± 50	Stuiver *et al.* 1981
QL171	Inexpressible Is.	Weddell seal	1912	1390 ± 40	928 ± 40	Stuiver *et al.* 1981
NZ6339A	Inexpressible Is.	Emperor penguin bones	1912	1065 ± 50	603 ± 50	Mabin 1985
NZ6327A	Inexpressible Is.	Weddell seal bones	1912	1760 ± 55	1298 ± 55	Mabin 1985
NZ6842A	Inexpressible Is.	Adélie penguin bones and flesh	1912	1060 ± 45	598 ± 45	Whitehouse *et al.* 1988
NZ6872	Inexpressible Is.	Charcoal from seal blubber stove	1912	1240 ± 45	778 ± 45	Greenfield in Whitehouse *et al.* 1988
GX-12759	Inexpressible Is.	Seal bones	1912	1175 ± 75	713 ± 75	Orombelli 1988
NZ7079A	Cape Evans	Emperor penguin bone collagen	1916	1105 ± 55	642 ± 55	Mabin 1986
NZ7076A	Cape Evans	Emperor penguin flesh and feathers	1916	1220 ± 55	757 ± 55	Mabin 1986
NZ6851A	Cape Evans	Weddell seal bone collagen	1916	1610 ± 80	1147 ± 80	Mabin 1986
GX-18581	68°30'S–67°00'W	*Adamussium colbecki*	1940	1476 ± 39	1001 ± 39	Berkman and Forman 1996
GX-18582	67°52'S–67°17'W	*Adamussium colbecki*	1940	1416 ± 40	941 ± 40	Berkman and Forman 1996
AA 14785	68°47'S–90°35'W	*Neobuccinum eotoni*	1917	1215 ± 57	750 ± 57	Berkman and Forman 1996
GX-19205	78°30'S–164°20'W	*Thracia meridionalis*	1935	1278 ± 62	798 ± 62	Berkman and Forman 1996

With our *Penguin* program it is easy to recalibrate the set of data using both the mean value calculated from all the available samples or different ΔRs obtained from penguin remains only. Furthermore, regional values can be calculated and compared for different sets of data.

Calibration is performed by the computer program CALIB (Stuiver and Reimer 1993); it allows the manual insertion of the data or can take as input a text file that can be created with a word processor. Normally, sample data (code, locality, description) are maintained using common commercial database programs, although the latter are not able either to export data directly in CALIB file format or to import data results (mainly calibrated age ranges) from CALIB output text files; in both cases data must be transferred one at time by retyping or through a tedious copy-and-paste process. Alternatively, sample data can be kept in CALIB input text files and handled with a word processor. However, because such programs are not aware of the format of those files, it is very easy to accidentally modify their structure, making them unreadable by CALIB.

Penguin's main goal is data management, focusing on data exchange with CALIB files in order to speed up the recalibration procedure. *Penguin* allows easy maintenance of sample data files, much like a database application. In our view, the program is particularly suited for the calibration procedure when one of the following conditions applies: 1) new ^{14}C dates are to be added to the set of data; 2) new samples of known age are supplied. In the first case, only the new conventional ages are to be calibrated, using one or more ΔR values. In the latter case, the ΔR values must be recalculated and the existing sets of ^{14}C dates must be recalibrated.

The usefulness of *Penguin* can be explained via an example (see the flow chart in Fig. 1). If we assume that new penguin remains (either bone or flesh) of historical known age have been discovered and dated, the existing ΔR value based on penguin remains must be updated in order to take into account the new *datum* (actually a weighted mean is computed of all the ΔR values derived from each dated sample). Then, this new ΔR value is used to recalibrate all the penguin ^{14}C dates.

If we have our sample data in a *Penguin* file called "MySamples" (Fig. 2), all we have to do is to open this file, assign the new ΔR value to all samples contained in the file and save a copy of the file in CALIB format. At this point we can use CALIB to calibrate all the dates. Calibration results are collected by CALIB in one

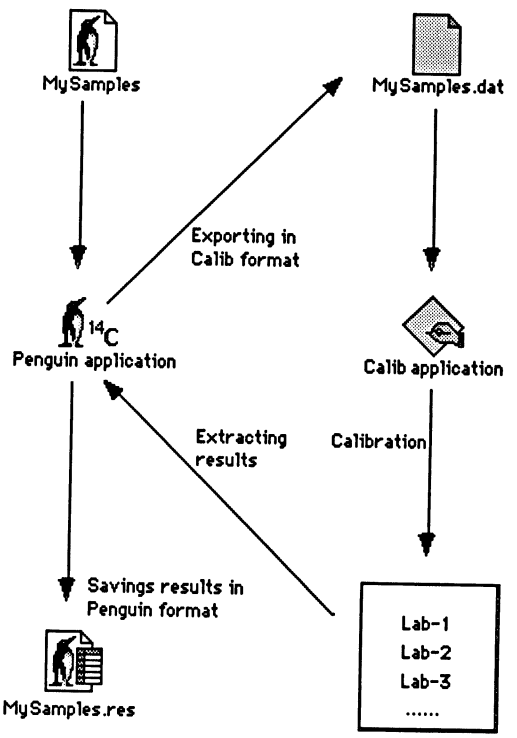

Fig. 1. Flowchart showing the role of *Penguin* in the calibration process. Data are kept in *Penguin* data files and CALIB input files are generated only when ^{14}C dates need to be calibrated. *Penguin* then puts into a unique file the calibration results extracted from each output file created by CALIB.

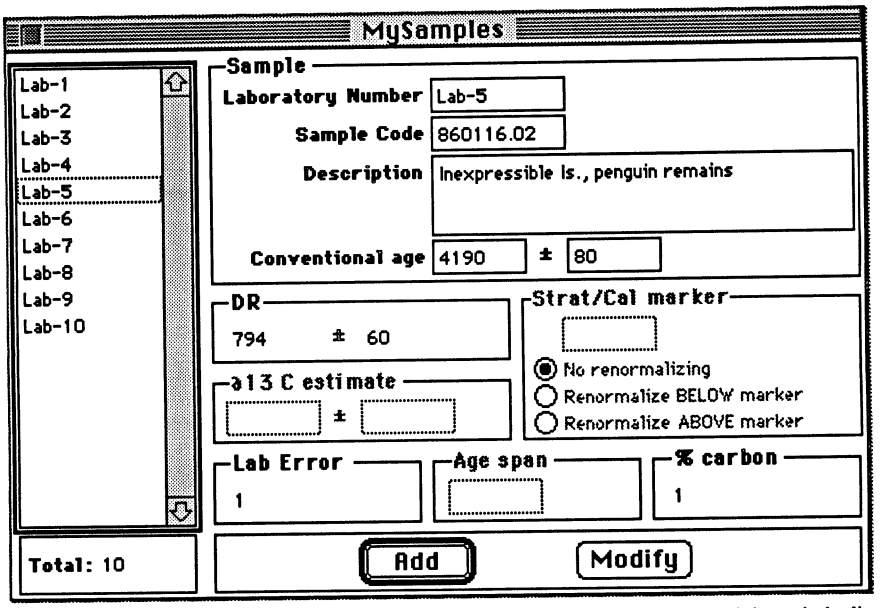

Fig. 2. *Penguin* allows easy editing of sample data files. Sample records are selected through the list on the left side of the window. Text boxes and radio buttons are provided for editing the content of the fields.

file for each sample, so after a calibration session there are as many files as the number of samples contained in the original input file. With *Penguin,* all these files can be parsed in order to extract the calibration results, which can be saved in unique file (Fig. 3). The current release of *Penguin* accepts only the calibrated age ranges from CALIB output files; future releases will allow extraction of all the other information. Furthermore, *Penguin* allows calibration results to be exported in standard text format files (variable-sized records with variable-sized fields separated by a tab character or comma) that can be directly read by database or spreadsheet programs.

Following a basic rule, common sample data should be kept in a *Penguin* file, which can be edited by either adding, deleting or modifying sample records; CALIB input files should be created only

MySamples.res

	Lab. number	Conv. Age	1 sigma range (B.P.)
1	Lab-1	2015 ± 75	875 (737) 659
2	Lab-2	4290 ± 50	3448 (3359) 3283
3	Lab-3	4495 ± 135	3806 (3602) 3423
4	Lab-4	5385 ± 85	4870 (4812) 4643
5	Lab-5	4190 ± 80	3360 (3254) 3119
6	Lab-6	4930 ± 85	4343 (4181) 4048
7	Lab-7	5770 ± 60	5427 (5295) 5232
8	Lab-8	5575 ± 185	5295 (5011) 4810
9	Lab-9	2900 ± 90	1805 (1681) 1533
10	Lab-10	5360 ± 90	4856 (4801) 4600

Fig. 3. Calibration results are displayed in a spreadsheet-like window

for calibration purposes and then deleted when they are no longer needed. Of course, for each set of ^{14}C dates there will be as many *Penguin* calibration result files as the number of times the same set of dates has been calibrated.

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