

A COMPUTER PROGRAM FOR RADIOCARBON AGE CALIBRATION

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The calibration curves and tables given in this issue of RADIOCARBON form a data base ideally suited for a computerized operation. The program listed below converts a radiocarbon age and its age error σ_s (one standard deviation) into calibrated ages (intercepts with the calibration curve), and ranges of calibrated ages that correspond to the age error. The standard deviation σ_c in the calibration curve is taken into account using $\sigma_{total} = \sqrt{\sigma_s^2 + \sigma_c^2}$ (see Stuiver and Pearson, this issue, for details).

The program transforms radiocarbon ages into cal AD/BC(cal BP) ages. Probabilities within the cal age ranges are not included, this feature will be incorporated at later stage. The FORTRAN program and calibration data can be obtained for the cost of materials and shipping (US \$5, prepaid and payable to the Quaternary Research Center) from the Quaternary Isotope Laboratory on a DS/DD floppy diskette. The calibration data were assembled from this calibration issue, and from the tabulations of Linick, Suess, and and Becker (Radiocarbon, 27, 20-32, 1985).

The current commitment of the Quaternary Isotope Laboratory is to supply the 1986 version of the program. We do not yet pledge continuous updating, but will make an attempt if time and budget permit. The program is IBM PC-XT compatible; users are responsible for adaptation to non-compatible systems. A visual display (although not given here) is part of the floppy disk version. Future use of the program will surely lead to modifications and we welcome suggestions.

C
C Radiocarbon Calibration Program CALIB
C

C The program converts radiocarbon ages to calibrated ages as
C would be done if one manually plotted the calibration curve data*
C on an X-Y axis and drew a line through the Y-axis corresponding to
C the radiocarbon age. Vertical lines drawn through these intercepts
C to the X-axis, with linear interpolation between data points, give
C the cal AD/BC ages. Cal BP ages are calculated from 1950 so that
C cal BP = 1950 - cal AD and cal BP = 1949 + cal BC. The one year
C difference in converting BC dates is caused by the absence of the
C zero year in the AD/BC chronology.

C To convert the standard error in the radiocarbon age into a range
C of cal AD/BC (BP) ages the user must first determine whether to use
C 1) the laboratory quoted error or 2) increase the quoted error by a
C known "error multiplier" (Stuiver and Pearson, 1986, Radiocarbon,
C 28, 805-838.) With the sample sigma entered, the program calculates
C the total sigma for non-marine samples as:

C 1 Sigma = SQRT((sample sigma)^2 + (calibration curve sigma)^2)
C 2 Sigma = SQRT((2*sample sigma)^2 + (calibration curve sigma)^2)

C (Stuiver, 1982, Radiocarbon, 24, 1-26). The calibration curve sigma
C is the average of the standard deviation of the 2 data points closest
C to each intercept of the radiocarbon age Y. Vertical lines drawn to
C the X-axis through the intercepts of Y + 1 Sigma and Y - 1 Sigma with
C the calibration curve give the ranges of cal AD/BC ages for 1 Sigma.
C Likewise intercepts of Y + 2 Sigma and Y - 2 Sigma give the 2 Sigma
C ranges. For ranges and sample sigmas greater than 100 years the
C ranges are rounded to the nearest ten years. Ranges that overlap or

C are closer together than one year, or ten if rounded, are reported as
C one age range.

C Marine samples are treated similarly except that the user must
C determine the Delta R and the uncertainty in Delta R to use for
C each sample based on its collection location (Stuiver, Pearson, and
C Braziunas, 1986, Radiocarbon, 28, 2B...) The marine total sigma is
C taken as:

C 1 Sigma = SQRT((sample sigma)^2 + (Delta R sigma)^2)
C 2 Sigma = SQRT((2*sample sigma)^2 + (Delta R sigma)^2).

C Three datasets are provided. The twenty year atmospheric record
C (2) is recommended for most non-marine samples although a ten year
C record (1) is given for more detailed comparisons of younger samples.
C The 20 year marine record (3) should be used with all marine samples.

C *Input from files:

C 1. ATM10.14C
C 10 yr atmospheric record to 2490 cal BC (circa 4200 14-C BP)
C 2. ATM20.14C
C 20 yr atmospheric record to 7210 cal BC (circa 8200 14-C BP)
C Format(1. and 2.): Year, Radiocarbon age, Sigma age
C (5X,F9.1,5X,I5,5X,I2)
C 3. MARINE.14C
C 20 yr marine model record to 7190 cal BC (circa 8585 14-C BP)
C Format: Year, Radiocarbon age
C (5X,F9.1,5X,I5)

C Output :

C 1. to printer LPT1 if desired
C 2. OUTFIL.14C for listing, rename to save
C 3. PLTFIL.14C for plotting
C Format: sample id, # of intercepts, calibrated ages
C 1 sigma value, # of ranges, ranges,
C 2 sigma value, # of ranges, ranges
C (1X,A12,I2,n(F10.1,2X))
C 2(1X,F8.1,I2,r(F10.1,2X))
C where n=repeat spec.= # of intercepts
C where r=repeat spec.= # of ranges

C Subroutines:

C INRCP to find the intercept of a radiocarbon age with the
C calibration curve
C Calling sequence: CALL INRCP(V,NPTS,INTPT,NINP)
C where:
C V = Y value (Radiocarbon age) to intercept curve
C NPTS = # of data points (current dimension = 1000)
C INTPT = array of intercepting points (max = 40)

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C          NINP = # of intercepting points
C
C ABWRT  writes calibrated age to unit LO
C
C BPWRT  writes age BP to unit LO
C
C RWRT   write age ranges to unit LO
C
C Revision date: 7/18/86
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C
$STORAGE:2
PROGRAM CALIB
C
COMMON X(1000),Y(1000),S(1000)
COMMON /WRRNG/ RANGE,SIGMA1,NRANG,NPTS,JAD
COMMON /WRINT/ ABINT,BPINT,ENLNE
C
INTEGER*2 AGE,ABINT,BPINT,INTX(40,2)
INTEGER*2 IRANGE(20,2)
INTEGER*2 LU(3),MINTX(40,2),MENT,NENT,NINP,NINTX(40,2)
INTEGER*2 RANK(80),SIGAGE,TREF
C
REAL*4 DELTAR,EINT(40)
REAL*4 INTPT(40),MINT(40),RAGE,RANGE(20,2)
REAL*4 REFDAT(4,2),SAMSIG,SIG1,SIG2,SIGMA1,TEMPR(40),UNCR
REAL*4 YMAX
C
CHARACTER COMMA*1,CHSIG*1
CHARACTER CHPM*1,CHSQD*1,FMT*100,IAD(3)*2,ICL*4
CHARACTER ID*2,IDSAM*12,JAD*2,LP*1,MREF(5)*1,NAME*10,NAMOUT*10
CHARACTER NAMPLT*10,NREF(6)*1,SREF(6)*21,SREF2(6)*21,SREF1*21
CHARACTER REF1*63,REF2(5)*63,REF3(2)*63,REFAL(9)*63
CHARACTER SREF3(2)*21,STR1*15,STR2*16
C
LOGICAL SKIP,ENLNE
C
EQUIVALENCE (ID,IDSAM)
C
DATA COMMA/','/,FMT/' '/
DATA LU/0,200,6/
DATA NAMOUT/'OUTFIL.14C'/,NAMPLT/'PLTFIL.14C'/
DATA NAME/'CAL20.14C'/,IAD/'AD','BP','AD'/,ICL/'cal '/
C
C Reference for 10 yr atmospheric record
C
DATA REF1/'Stuiver,M and Becker,B, 1986, Radiocarbon, 28, 2B....'/
DATA SREF1/'(Stuiver and Becker) '/
C
C References for 20 yr atmospheric record
C
DATA REF2/
&'Stuiver, M and Pearson, GW, 1986, Radiocarbon, 28, 805-838.',
&'Pearson, GW and Stuiver, M, 1986, Radiocarbon, 28, 839-632. ',
&'Pearson, GW, Pilcher, JR, Baille, MG, Corbett, DM and Qua, F, ',
&'1986, Radiocarbon, 28, 2B.....',
&'Bidecadal weighted average of data from: '/
DATA REFAL/'Linick, TW, Suess, HE and Becker, B, (LSB) 1985, ',
&'Radiocarbon, 27, 20-32. [for the interval 5219-7199 BC ',
&'Stuiver, M, Kromer, B, Becker, B, and Ferguson, CW, (SKBF) ',
&'1986, Radiocarbon, 28, 2B....',
&'Kromer, B, Rhein, M, Bruns, M, Schoh-Fischer, H, Munnich, KO,',
&'Stuiver, M, and Becker, B, (KRBSMSB) 1986, Radiocarbon, 28,',
&'2B..... [for the interval 5229 -7207 BC]',
&'Linick, TW, Long, A, Damon, PE and Ferguson, CW, (LLDF) 1986.',
&'Radiocarbon, 28, 2B.'/
C
DATA SREF2/'(Stuiver and Pearson)','(Pearson and Stuiver)',
&'(Pearson et al. 1986)','(20 yr. average of ',
&' LSB,SKBF,KRBSMSB,', ' and LLDF)'/
C
DATA REF3/'Stuiver, M, Pearson, GW, and Braziunas, T, 1986.',
&'Radiocarbon, 28, 2B.'/
DATA SREF3/'(Stuiver, Pearson and', ' Braziunas) '/
C
DATA STR1/'Calibrated age:/',STR2/'Calibrated ages:/'
C
define character Plus and minus, sigma, and squared and formfeed
C
CHPM = CHAR(241)
CHSIG = CHAR(229)
CHSQD = CHAR(253)
C
C Open files for text output and plotting
C
OPEN(6,FILE='LPT1')
OPEN(200,FILE=NAMOUT,STATUS='NEW')
OPEN(300,FILE=NAMPLT,STATUS='NEW')
DO 20 IWRITE=1,3
LO=LU(IWRITE)
IF(IWRITE.GT.2) THEN
WRITE(*,25)
FORMAT(1X,'Output to Printer? Y(es) or N(o) ')
READ(*,'(A)') LP
IF((LP.NE.'Y').AND.(LP.NE.'y')) THEN
LEND = 2
GOTO 20
ELSE
LEND = 3
ENDIF
ENDIF
WRITE(LO,'(26X,A)') 'UNIVERSITY OF WASHINGTON'
WRITE(LO,'(27X,A)') 'QUATERNARY ISOTOPE LAB'
WRITE(LO,'(23X,A)') 'RADIOCARBON CALIBRATION PROGRAM 1986'
WRITE(LO,*)
20 CONTINUE
WRITE(*,30)
FORMAT(/,1X,'Select calibration curve dataset.',/,1X,
&'1. 10 yr atmospheric record to 2490 cal BC (circa 4200 14-C BP)',
&/,1X,
&'2. 20 yr atmospheric record to 7210 cal BC (circa 8200 14-C BP)',
&/,1X,
&'3. 20 yr marine model to 7190 cal BC (circa 8585 14-C BP)')
WRITE(*,40)

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40  FORMAT(/,1X,'Enter selection:  '\)
    READ(*,*) ISET
    IF(ISET.GT.2) THEN
        NAME = 'MARINE.14C'
    ELSEIF (ISET.GT.1) THEN
        NAME = 'ATM20.14C '
    ELSE
        NAME = 'ATM10.14C '
    ENDIF
C
C Read calibration file
C
    WRITE(*,50)
50  FORMAT(/,3X,'READING CALIBRATION FILE---PLEASE WAIT ',/)
    OPEN(100,FILE=NAME)
    I = 1
100  IF(ISET.LT.3) THEN
        READ(100,110,END=180,ERR=970) YEAR,AGE,SIGAGE
110  FORMAT(5X,F9.1,5X,I5,5X,I2)
        X(I) = YEAR
        Y(I) = FLOAT(AGE)
        S(I) = FLOAT(SIGAGE)
    ELSE
        READ(100,120,END=180,ERR=970) YEAR,AGE
120  FORMAT(5X,F9.1,5X,I5)
        X(I) = YEAR
        Y(I) = FLOAT(AGE)
    ENDIF
    NPTS = I
    I = I + 1
    GOTO 100
180  NSAM = 0
    DO 185 J=1,4
        MREF(J) = ' '
185  CONTINUE
    YMAX = -1E30
    DO 190 J=1,NPTS
        YMAX = AMAX1(Y(J),YMAX)
190  CONTINUE
200  DO 250 I=1,LEND
        LO=LU(I)
        WRITE(LO,205) NAME
205  FORMAT(1X,'Calibration file: ',A10,/)
        WRITE(LO,210)
210  FORMAT(' Lab #',11X,'Radiocarbon',4X,'calibrated age(s)',
    & 9X,'References')
        WRITE(LO,220)
220  FORMAT(' ',18X,'Age BP')
250  CONTINUE
300  WRITE(*,*)
    WRITE(200,'(//)')
305  WRITE(*,310)
310  FORMAT(' Enter sample ID (or XX to end)')
    READ(*,320) IDSAM
320  FORMAT(A12)
    IF((ID.EQ.'XX').OR.(ID.EQ.'xx')) GOTO 1000
    WRITE(*,330) COMMA
330  FORMAT(' Enter radiocarbon age BP',A,' standard error ')
    READ(*,*) RAGE,SAMSIG
    IF((RAGE.LE.0.0).OR.(RAGE.GE.YMAX)) THEN
        WRITE(*,340) 0,INT(YMAX-.5)
340  FORMAT(' VALID RADIOCARBON AGES FOR THIS DATA MUST BE BETWEEN',
    &I2,' AND',I5,' YRS BP')
        GOTO 305
    ENDIF
C
C For Marine samples, enter reservoir correction Delta R.
C Default Reservoir correction is 400 yrs, Delta R = 0.
    IF(ISET.GT.2) THEN
        DELTAR=0.0
        UNCR=0.0
        WRITE(*,350)
350  FORMAT(1X,'Enter reservoir correction Delta R')
        READ(*,*) DELTAR
        WRITE(*,360)
360  FORMAT(1X,'Enter Delta R standard deviation')
        READ(*,*) UNCR
    ENDIF
C
C Print sample ID and age
    DO 375 IWRITE=1,LEND
        LO=LU(IWRITE)
        WRITE(LO,370) IDSAM,RAGE,CHPM,SAMSIG
370  FORMAT(/,1X,A12,2X,F6.1,A3,F5.1,3X,\)
375  CONTINUE
C
C Subtract reservoir correction and add estimated extension to marine
C model
    IF(ISET.GT.2) THEN
        RAGE = RAGE - DELTAR
        NPTS = NPTS + 1
        X(NPTS) = 1954.
        Y(NPTS) = 493.
    ENDIF
C
C Add estimated bomb carbon influence to dataset
    NPTS = NPTS + 1
    X(NPTS) = 1955.
    Y(NPTS) = 0.
    S(NPTS) = 32.
C
C Find intercepts of Radiocarbon age with calibration curve
380  CALL INRCP(RAGE,NPTS,INTPT,NINP,INTX)
C
C Consolidate intercepts that round to the same year
C
400  DO 420 K=1,NINP-1
        INK1 = NINT(INTPT(K))
        INK2 = NINT(INTPT(K+1))
        IF(IABS(INK1-INK2).LT.1) THEN
            DO 410 K2=K+1,NINP-1
                INTPT(K2) = INTPT(K2+1)
410  CONTINUE
            NINP = NINP-1
        ENDIF
420  CONTINUE
C
C Write to plot file PLTFIL.14C
C
    WRITE(FMT,430) NINP
430  FORMAT(' (1X,A12,I2,'I2,'(F10.1,2X))')
    WRITE(300,FMT) IDSAM,NINP,(INTPT(K),K=1,NINP)

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C
C Write to OUTFIL.14C for later listing, to screen, and printer
C
  DO 590 IWRITE=1,LEND
    LO = LU(IWRITE)
C
C Check calibrated ages for appropriate references. If age falls
C between datasets give both references.
C
  KREF = 1
  IF(ISET.GT.2) THEN
    SREF(1) = SREF3(1)
    SREF(2) = SREF3(2)
    JREF=2
  ELSEIF (ISET.GT.1) THEN
    TREF = 4
    IREF = 4
    DO 450 K=1,TREF
      NREF(K) = 'N'
      SREF(K) = ' '
450    CONTINUE
    DO 510 K=1,NINP
      DO 500 J=1,4
        IF(INTPT(K).LT.REFDAT(J,2)) THEN
          IF(INTPT(K).GT.REFDAT(J+1,1)) THEN
            NREF(J) = 'Y'
            NREF(J+1) = 'Y'
            MREF(J) = 'Y'
            MREF(J+1) = 'Y'
            GOTO 510
          ENDIF
        ELSE
          NREF(J) = 'Y'
          MREF(J) = 'Y'
          GOTO 510
        ENDIF
      CONTINUE
500    CONTINUE
510    CONTINUE
    IF(NREF(4).EQ.'Y') THEN
      NREF(5) = 'Y'
      NREF(6) = 'Y'
      TREF = 6
    ENDIF
    JREF = 0
    DO 515 K=1,TREF
      IF(NREF(K).EQ.'Y') THEN
        JREF = JREF + 1
        SREF(JREF) = SREF2(K)
515    CONTINUE
    ELSE
      SREF(1) = SREF1
      JREF = 1
    ENDIF
C
C Set label to AD or BC
C
  IF(INTPT(1).LT.0.0) THEN
    IAD(1) = 'BC'
  ELSE
    IAD(1) = 'AD'
  ENDIF

```

```

  WRITE(LO,'(A4,A2,1X\')') ICL,IAD(1)
C
C Print calibrated ages
C
  DO 530 K=1,NINP
    J = K - 1
    ENLNE = .FALSE.
    IF((MOD(K,3).LE.0).OR.(K.EQ.NINP)) ENLNE = .TRUE.
    IF((MOD(J,3).LE.0).AND.(J.NE.0)) WRITE(LO,'(39X\')')
    ABINT = NINT(INTPT(K))
C
C Check to see if age will print out as zero then change to 1 , since
C there is no 0 AD/BC
C
    IF(ABINT.EQ.0) ABINT=1
    IF(INTPT(K).LT.0.0) THEN
      JAD = 'BC'
    ELSE
      JAD = 'AD'
    ENDIF
    IF(IAD(1).NE.JAD) THEN
      WRITE(LO,'(1X,A4,A2,\')') ICL,JAD
    ENDIF
    CALL ABWRT(LO)
    IF(ENLNE) THEN
      IF(KREF.LE.JREF) THEN
        IF(MOD(K,3).EQ.2) WRITE(LO,'(6X\')')
        IF(MOD(K,3).EQ.1) WRITE(LO,'(12X\')')
        WRITE(LO,'(2X,A21)') SREF(KREF)
        KREF=KREF + 1
      ELSE
        WRITE(LO,*)
      ENDIF
    ENDIF
530    CONTINUE
C
C calculate ages BP
C
  IF(ISET.GT.2) THEN
    WRITE(LO,535) DELTAR,CHPM,UNCR,ICL,IAD(2)
535    FORMAT(4X,'Delta R = ',F7.1,1X,A,F5.1,4X,A4,A2,1X\')
  ELSE
    WRITE(LO,'(32X,A4,A2,1X\')') ICL,IAD(2)
  ENDIF
  DO 540 K=1,NINP
    J = K - 1
    ENLNE = .FALSE.
    IF((MOD(K,3).LE.0).OR.(K.EQ.NINP)) ENLNE = .TRUE.
    IF((MOD(J,3).LE.0).AND.(J.NE.0)) WRITE(LO,'(39X\')')
    ABINT=NINT(ABS(INTPT(K)))
    IF(ABINT.EQ.0) ABINT = 1
    IF(INTPT(K).LT.0.0) THEN
      BPINT=1949 + ABINT
    ELSE
      BPINT=1950 - ABINT
    ENDIF
    CALL BPWRT(LO)
    IF(ENLNE) THEN
      IF(KREF.LE.JREF) THEN
        IF(MOD(K,3).EQ.2) WRITE(LO,'(6X\')')
        IF(MOD(K,3).EQ.1) WRITE(LO,'(12X\')')

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        WRITE(LO,'(2X,A21)') SREF(KREF)
        KREF=KREF+1
    ELSE
        WRITE(LO,*)
    ENDIF
    ENDIF
540 CONTINUE
550 IF(KREF.LE.JREF) THEN
        WRITE(LO,'(57X,A21)') SREF(KREF)
        KREF=KREF+1
        GOTO 550
    ENDIF
590 CONTINUE
    JAD = IAD(1)
    IF(ISET.LT.3) THEN
C
C Take calibration curve sigma to be the average of the nearest
C points to the intercepts
C Note: Y(INTX(I,1)) <= INTPT(I) < Y(INTX(I,2))
C Where INTX(I,1) and INTX(I,2) are array elements of the data
C
        SIG1 = 0.0
        DO 610 I=1,NINP
            SIG1 = SIG1 + (S(INTX(I,1)) + S(INTX(I,2)))/2.0
610 CONTINUE
        SIG1 = SIG1/NINP
    ELSE
C
C For marine samples the standard deviation in Delta R takes the
C place of the unknown model calibration curve sigma.
C
        SIG1 = UNCR
    ENDIF
    DO 625 IWRITE=1,LEND
        LO=LU(IWRITE)
        WRITE(LO,620) IAD(1),IAD(2)
620 FORMAT(' Sigma**      and cal ',A2,'(cal ',A2,') ranges:')
625 CONTINUE
C
C Find intercepts with RAGE +/- SIGMA1 for 1 and 2*SAMSIG
C
        DO 890 IR=1,2
            SIGMA1 = SQRT(SAMSIG**2 + SIG1**2)
            V=RAGE + SIGMA1
            CALL INRCP(V,NPTS,EINT,NENT,NINTX)
            V=RAGE - SIGMA1
630 CALL INRCP(V,NPTS,MINT,MENT,MINTX)
C
C Put both sets of intercepts in temporary storage.
C
C If there are no intercepts (NENT = 0) at the old end of
C the curve, assign the last year in the dataset
C
        IF(NENT.LE.0) THEN
            TEMPR(1) = X(1)
            INTX(1,1) = 1
            INTX(1,2) = 1
            NENT = 1
        ELSE
            DO 640 I=1,NENT
                TEMPR(I) = EINT(I)

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            INTX(I,1) = NINTX(I,1)
            INTX(I,2) = NINTX(I,2)
640 CONTINUE
        ENDIF
C
C The modern end of the curve will always have intercepts, though
C perhaps only with bomb 14C (1955*).
C
        DO 647 I=1,MENT
            TEMPR(NENT+I) = MINT(I)
            INTX(NENT+I,1) = MINTX(I,1)
            INTX(NENT+I,2) = MINTX(I,2)
647 CONTINUE
C
C LENT = total # of intercepts of age + sigma and age - sigma with
C the calibration curve.
C
        LENT = MENT + NENT
C
C Rank intercepts from oldest to youngest.
C
        DO 648 I=1,LENT
            RANK(I) = I
648 CONTINUE
        DO 660 I=2,LENT
            IPNT = RANK(I)
            J = I - 1
            JPNT = RANK(J)
            IF(TEMPR(IPNT).GE.TEMPR(JPNT)) GOTO 660
            KEEP = IPNT
            RANK(I) = JPNT
            DO 654 K=J-1,1,-1
                IF(K.EQ.0) GOTO 655
                KPNT = RANK(K)
                IF(TEMPR(KPNT).GT.TEMPR(IPNT)) THEN
                    RANK(K+1) = KPNT
                ELSE
                    GOTO 660
                ENDIF
            ENDIF
654 CONTINUE
655 RANK(K+1) = KEEP
660 CONTINUE
C
C Find ranges from ranked intercepts
C
        ICN = 0
        RS1 = RAGE + SIGMA1
        RS2 = RAGE - SIGMA1
        SKIP = .FALSE.
        DO 690 I=1,LENT-1
            IF(.NOT.SKIP) THEN
                IP1 = I+1
                IZ = INTX(RANK(I),1)
                NEXT = INTX(RANK(IP1),1)
C
C If age +/- sigma intercept is a single point, skip it
C
                IF((Y(IZ).EQ.RS1).AND.(Y(NEXT).GT.RS1)) GOTO 690
                IF((Y(IZ).EQ.RS2).AND.(Y(NEXT).LT.RS2)) GOTO 690
C

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C Assign range values from TEMPR according to RANK
C
      ICN = ICN+1
      RANGE(ICN,1) = TEMPR(RANK(I))
      RANGE(ICN,2) = TEMPR(RANK(IP1))
C
C If intercept is a turning point in the curve , share it
C with the next range, otherwise skip to next I
C
      IF((Y(IZ).NE.RS2).AND.(Y(IZ).NE.RS1)) THEN
        SKIP = .TRUE.
      ELSE
        SKIP=.FALSE.
      ENDIF
      ELSE
        SKIP=.FALSE.
      ENDIF
      ENDIF
690 CONTINUE
      NRANG = ICN
C
C Consolidate ranges that overlap or have gaps < 10 years
C NRANG = # of distinct ranges
C
729 ICN = 1
730 IF(ICN.GE.NRANG) GOTO 740
      ICNP1 = ICN + 1
C
C Replace overlapping ranges with maximum and minimum values
C
      IF((RANGE(ICN,2).GE.RANGE(ICNP1,1)).OR.
& ((RANGE(ICNP1,1)-RANGE(ICN,2)).LT.10.))THEN
        RANGE(ICN,1) = AMIN1(RANGE(ICNP1,1),RANGE(ICN,1))
        RANGE(ICN,2) = AMAX1(RANGE(ICNP1,2),RANGE(ICN,2))
C
C Move rest of ranges into empty slot
      DO 735 K2=ICNP1,NRANG-1
        K2P1 = K2 + 1
        RANGE(K2,1) = RANGE(K2P1,1)
        RANGE(K2,2) = RANGE(K2P1,2)
735 CONTINUE
        NRANG = NRANG - 1
        GOTO 730
      ENDIF
      ICN = ICN + 1
      GOTO 730
740 WRITE(FMT,741) ICN
      WRITE(300,FMT) SIGMA1,ICN,(RANGE(I,1),
& RANGE(I,2),I=1,ICN)
741 FORMAT('(1X,F8.1,I2,'I2','(F10.1,2X,F10.1))')
C
C Print ranges
C
      DO 885 IWRITE=1,LEND
        LO = LU(IWRITE)
        WRITE(LO,750) IR,CHSIG,SIGMA1
750 FORMAT(' ',I2,1X,A,' = ',F5.1,3X\')
        DO 880 I=1,NRANG
          CALL RWRT(LO,I)
C
C Skip to next line after 2 ranges are written
      IF((MOD(I,2).EQ.0).AND.(I.NE.NRANG)) WRITE(LO,'(/,16X,\)')
880 CONTINUE
        WRITE(LO,*)
885 CONTINUE
        SAMSIG = 2.0*SAMSIG
890 CONTINUE
C
C Form feed after 8 samples and write headings again
C
      NSAM = NSAM + 1
      IF((LP.EQ.'Y').AND.(MOD(NSAM,6).EQ.0)) THEN
        WRITE(6,891)
891 FORMAT('1RADIOCARBON CALIBRATION PROGRAM')
        WRITE(6,205) NAME
        WRITE(6,210)
        WRITE(6,220)
      ENDIF
      GOTO 300
970 WRITE(*,975)
975 FORMAT(' ERROR IN FILE READ')
1000 WRITE(*,1001)
1001 FORMAT(1X,'CLOSING FILES')
      CLOSE(100)
C
C Form feed to leave room for references if necessary
      LSAM = 5
      IF(ISET.EQ.2) LSAM = 3
      IF((MOD(NSAM,6).GE.LSAM).AND.(LP.EQ.'Y')) THEN
        WRITE(6,1002)
1002 FORMAT('1')
      ENDIF
      DO 1200 IWRITE=1,LEND
        LO = LU(IWRITE)
        WRITE(LO,'(///)')
        WRITE(LO,1003)
1003 FORMAT(1X,'References for datasets [and intervals] used:')
        IF(ISET.GT.2) THEN
          WRITE(LO,1010) REF3(1),REF3(2)
          ELSEIF (ISET.GT.1) THEN
            J = 0
            DO 1005 K=1,IREF
              J = J + 1
              IF(MREF(K).EQ.'Y') THEN
                WRITE(LO,1010) REF2(J)
                IF(K.EQ.3) THEN
                  J = J + 1
                  WRITE(LO,1010) REF2(J)
                ENDIF
              IF(K.GT.3) THEN
                DO 1004 IRF=1,8
                  WRITE(LO,1010) REFAL(IRF)
1004 CONTINUE
                ENDIF
              ENDIF
            ENDIF
          CONTINUE
          ELSE
            WRITE(LO,1010) REF1
          ENDIF
1010 FORMAT(1X,A63)
        WRITE(LO,1015)
1015 FORMAT(/,1X,'Comments:')

```

```

1020 WRITE(LO,1020)
      FORMAT(1X,'1955* represents influence of bomb C-14')
      WRITE(LO,1030)
1030 FORMAT(1X,'0* represents a "negative" age BP')
      IF(ISET.LT.3) THEN
          WRITE(LO,1040) CHSQD,CHSQD
1040     FORMAT(1X,'** 1 sigma = square root of (sample sigma',A,
      & '+ curve sigma', A,')')
          WRITE(LO,1050) CHSQD,CHSQD
1050     FORMAT(1X,' 2 sigma = square root of [(2 sample sigma)',A,
      & '+ curve sigma', A,']')
          WRITE(LO,1060) IABS(NINT(X(1)))
1060     FORMAT(1X,'>',I5,' BC represents end of calibration data ')
      ELSE
          WRITE(LO,1070) CHSQD,CHSQD
1070     FORMAT(1X,'** 1 sigma = square root of (sample sigma',A,
      & '+ uncertainty in Delta R', A,')')
          WRITE(LO,1080) CHSQD,CHSQD
1080     FORMAT(1X,' 2 sigma = square root of [(2 sample sigma)',A,
      & '+ Delta R sigma', A,']')
          WRITE(LO,1090) IABS(NINT(X(1)))
1090     FORMAT(1X,'>',I5,' BC represents end of calibration data ')
      ENDIF
1200 CONTINUE
2000 END
C
C
      SUBROUTINE INRCP(V,N,INTPT,NINPT,XYINT)
C
C Subroutine to find the intercepts of V with the straight line
C between two points of a dataset
C
C V = Y value for which the intercepts with the function are desired
C
C INTPT = array of intercepting points
C NINPT = # of intercepts
C N = # of data points
C XYINT = element #'s of the data array that V falls between
C
C
      COMMON X(1000),Y(1000),S(1000)
C
      REAL*4 V,INTPT(40),M,B,X3
      INTEGER*2 N,NINPT,XYINT(40,1)
C
      NINPT=0
10 DO 100 I=2,N
      X1 = X(I-1)
      X2 = X(I)
      Y1 = Y(I-1)
      Y2 = Y(I)
      IF(((V.GE.Y1).AND.(V.LT.Y2)).OR.((V.LE.Y1).AND.(V.GT.Y2))) THEN
          M = (Y2-Y1)/(X2-X1)
          B = Y1 - M*X1
          X3 = (V-B)/M
          NINPT = NINPT + 1
          INTPT(NINPT) = X3
          XYINT(NINPT,1) = I-1
          XYINT(NINPT,2) = I
      ENDIF

```

```

100 CONTINUE
      RETURN
      END
C
      SUBROUTINE ABWRT(LO)
C
      COMMON /WRINT/ABINT,BPINT,ENLNE
C
      CHARACTER MARK*1,COMMA*1
      INTEGER ABINT,BPINT,LO,NBINT
      LOGICAL ENLNE
C
      COMMA = ','
      MARK = '**'
C
      NBINT = IABS(ABINT)
      IF(ABINT.LT.1954) THEN
          IF(ENLNE) THEN
              WRITE(LO,'(1X,I4\')') NBINT
          ELSE
              WRITE(LO,'(1X,I4,A\')') NBINT,COMMA
          ENDIF
      ELSE
          NBINT = 1955
          IF(ENLNE) THEN
              WRITE(LO,'(1X,I4,A\')') NBINT,MARK
          ELSE
              WRITE(LO,'(1X,I4,2A\')') NBINT,MARK,COMMA
          ENDIF
      ENDIF
      RETURN
      END
C
      SUBROUTINE BPWRT(LO)
C
      COMMON /WRINT/ ABINT,BPINT,ENLNE
C
      CHARACTER MARK*1,COMMA*1
      INTEGER ABINT,BPINT,LO
      LOGICAL ENLNE
C
      COMMA = ','
      MARK = '**'
C
      IF(BPINT.GE.0) THEN
          IF(ENLNE) THEN
              WRITE(LO,'(1X,I4\')') BPINT
          ELSE
              WRITE(LO,'(1X,I4,A\')') BPINT,COMMA
          ENDIF
      ELSE
          BPINT = 0
          IF(ENLNE) THEN
              WRITE(LO,'(1X,I4,A\')') BPINT,MARK
          ELSE
              WRITE(LO,'(1X,I4,2A\')') BPINT,MARK,COMMA
          ENDIF
      ENDIF
      RETURN
      END

```

```

C
C
C SUBROUTINE RWRT(LO,IR)
COMMON X(1000),Y(1000),S(1000)
COMMON /WRRNG/ RANGE,SIGMA1,NRANG,NPTS,JAD
C
REAL*4 RANGE(20,2),SIGMA1
INTEGER NRANG,IRANGE(2),BRANG(2)
CHARACTER IAD(3)*2,ICL*4,DASH*1,JAD*2,KAD*2,RMARK*1
C
DATA DASH/'-'/
DATA ICL/'cal '/
C
RANGT = ABS(RANGE(IR,2)-RANGE(IR,1))
ISIG = NINT(SIGMA1)
C
C Round range values to nearest ten if sigma > 100 and RANGE > 100 years
C Leave out ranges that will round to the same year (or ten years).
C
IF((ISIG.GE.100).AND.(RANGT.GE.100.)) THEN
  IRANGE(1) = NINT(RANGE(IR,1)/10.) * 10
  IRANGE(2) = NINT(RANGE(IR,2)/10.) * 10
ELSE
  IRANGE(1)=NINT(RANGE(IR,1))
  IRANGE(2)=NINT(RANGE(IR,2))
ENDIF
IF(IABS(IRANGE(1)-IRANGE(2)).GT.1) THEN
C
C Calculate BP ranges
C
DO 100 J=1,2
  K = 2*J - 1
  IF(RANGE(IR,J).LT.0.0) THEN
    BRANG(J) = 1949 - IRANGE(J)
    IAD(K) = 'BC'
  ELSE
    BRANG(J) = 1950 - IRANGE(J)
    IAD(K) = 'AD'
  ENDIF
100 CONTINUE
C
C Check to see if range is going to print out as zero then change
C to 1, since there is no 0 AD/BC.
C
150 DO 180 J=1,2
  IF (IRANGE(J).EQ.0) THEN
    IF(RANGE(IR,J).LT.0.0) THEN
      BRANG(J) = 1950
      IRANGE(J) = -1
    ELSE
      BRANG(J) = 1949
      IRANGE(J) = 1
    ENDIF
  ENDIF
180 CONTINUE
C
C 1954 AD is last possible year, since after 1954, the bomb C-14 signal
C overwhelmed the natural variations; therefore any range >1954 AD prints
C 1955* and 0* BP.
C

```

```

KAD=JAD
DO 200 J=1,2
  K=2*J-1
  IF(RANGE(IR,J).GT.1954.) THEN
    IRANGE(J) = 1955
    RMARK = '*'
C
C Check to see if RANGE(IR,1) and RANGE (IR,2) are either both AD
C OR both BC and the same as the heading printed for calibrated ages.
C
IF((IAD(1).EQ.IAD(3)).AND.(IAD(1).EQ.KAD)) THEN
  WRITE(LO,'(I4,A\')') IRANGE(J),RMARK
ELSE
  WRITE(LO,'(A4,A2,I4,A\')') ICL,IAD(K),IRANGE(J),RMARK
  KAD=IAD(1)
ENDIF
C
C X(1) is the first cal year for the dataset. Any range value >= X(1)
C prints as >X(1) and >(1949-X(1)) BP though the actual range is
C unknown
C
ELSEIF (RANGE(IR,J).LE.X(1))THEN
  IRANGE(J) = NINT(ABS(X(1)))
  RMARK = '>'
  IF((IAD(1).EQ.IAD(3)).AND.(IAD(1).EQ.KAD)) THEN
    WRITE(LO,'(A,I4\')') RMARK,IRANGE(J)
  ELSE
    WRITE(LO,'(A4,A2,A,I4\')') ICL,IAD(K),RMARK,IRANGE(J)
    KAD=IAD(1)
  ENDIF
ELSE
  IRANGE(J) = IABS(IRANGE(J))
  IF((IAD(1).EQ.IAD(3)).AND.(IAD(1).EQ.KAD)) THEN
    WRITE(LO,'(I4\')') IRANGE(J)
  ELSE
    WRITE(LO,'(A4,A2,I4\')') ICL,IAD(K),IRANGE(J)
    KAD=IAD(1)
  ENDIF
ENDIF
IF(J.LT.2) WRITE(LO,'(A\')') DASH
200 CONTINUE
C
C Write BP ranges
C
LSTBP=1949-NINT(X(1))
DO 350 J=1,2
  IF(J.LT.2) THEN
    WRITE(LO,310)
    FORMAT('('\)
310 CONTINUE
ENDIF
IF(BRANG(J).LT.0) THEN
  BRANG(J) = 0
  RMARK = '*'
  WRITE(LO,'(I4,A\')') BRANG(J),RMARK
ELSEIF (BRANG(J).GE.LSTBP) THEN
  BRANG(J) = LSTBP
  RMARK = '>'
  WRITE(LO,'(A,I4\')') RMARK,BRANG(J)
ELSE
  WRITE(LO,'(I4\')') BRANG(J)
ENDIF

```

```
IF(J.LT.2) THEN
  WRITE(LO,'(A\')') DASH
ELSE
  WRITE(LO,320)
320   FORMAT(')',1X\
ENDIF
350   CONTINUE
ELSEIF (IRANGE(1).GE.1954) THEN
  RMARK='*'
  IRANGE(1) = 1955
  WRITE(LO,'(I4,A\')') IRANGE(1),RMARK
ENDIF
RETURN
END
```

ERRATUM. Format 1070 should read:

```
1070   FORMAT(1X,'** 1 sigma = square root of (sample sigma',A,
&      '+ Delta R sigma',A,')')
```