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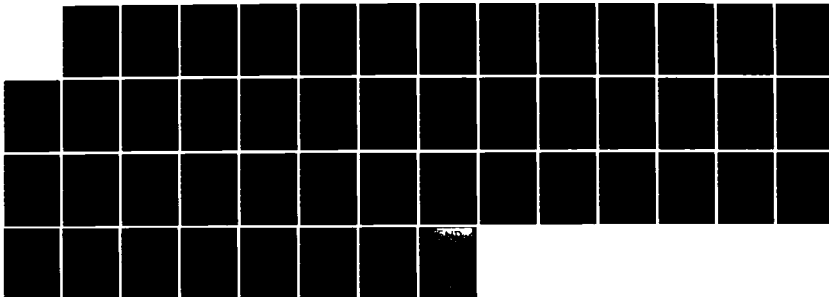
TIME SERIES ANALYSIS PROGRAMS FOR STRATIGRAPHIC DATA
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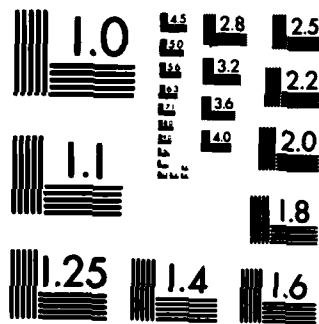
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TIME SERIES ANALYSIS PROGRAMS FOR STRATIGRAPHIC DATA

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This report documents a set of FORTRAN programs and subroutines for analyzing stratigraphic time series data. Each project is briefly explained to provide a context for the programs. All algorithms used in the project are also explained. All programs were written for the UCSD Vax 11/780 (VMS) computer.		

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TIME SERIES ANALYSIS PROGRAMS FOR STRATIGRAPHIC DATA

Paul Schiffelbein

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I. Introduction

This report documents a set of FORTRAN programs and subroutines for analyzing stratigraphic time series data. These programs were written as part of the author's Ph.D. dissertation (Schiffelbein, 1984) and can be considered as an appendix to that work. This documentation is divided into two sections. The first section follows the organization of the author's thesis. Each project is briefly explained to provide a context for the programs. All algorithms used in the project are also explained. The second section provides an alphabetical listing of the algorithms referred to in the first section. All programs were written for the UCSD Vax 11/780 (VMS) computer. Subroutines referred to in the programs but not listed (CARTESIAN, CLEAR, COMPLEX, CONVOLVE, FFT, FFTINVERSE, INTERPOLATE, POLAR, POWER, POWERDB, PROLATE, REALPART, ZEROMEAN) are from a library kindly made available to the author by Alan Chave and are described and listed in Chave (1980).

II. Project and Program Descriptions

A. The Effect of Benthic Mixing on the Information Content of
Deep-Sea Stratigraphic Signals

Abstract (Chapter 3 of the dissertation):

Benthic mixing or bioturbation affects sediments in a number of ways, including 1) the production of trace fossils, 2) mechanical and/or chemical alteration of the sediment, and 3) filtering or smearing stratigraphic signals. Since mixing alters both the slopes and amplitudes of any recorded events, some knowledge of the process is essential for correct interpretation of the signals. Particularly in the light of recent trends towards high-resolution stratigraphy and signal unmixing, the frequency characteristics of the benthic mixing filter must be understood to know which types of signals can be detected after mixing. Ash and tektite profiles in deep-sea cores from various geographic regions are examined in the frequency domain to determine the characteristics of the benthic mixing process. Analysis of these profiles indicates that even signals from cores having sedimentation rates as high as 7 cm/ka will show severe attenuation of frequencies higher than 0.35 cycles/ka (periods shorter than 2.9 ka) resulting in loss of the ability to resolve closely-spaced events. Most signals will experience much more serious high-frequency attenuation, however. The severity of high frequency loss is directly related to sedimentation rate ($R = 0.97$ for the cores examined), suggesting that this is the most

important variable when considering a core for
paleoceanographic or paleoclimatic study.

1. Program PROJECT: This program computes the power spectrum of an impulse response function (IRF). The IRF is stored in some input file. The power spectrum is given in decibels and stored in a user-specified output file.
2. Program GSTEST is a simple driver program for the subroutine GSIRF. The user is asked for the benthic mixing parameters, which are passed to GSIRF, and the mixing function is generated and stored in a user-specified file.
3. Subroutine GSIRF uses the approximation equation of Officer and Lynch (1983) as a solution to the benthic mixing equation of Guinasso and Schink (1975). The subroutine is accessed by a statement:

CALL GSIRF [generated IRF vector, mixed layer thickness (cm), diffusion coefficient (cm^2/ka), sedimentation rate (cm/ka)]. The output is the benthic mixing impulse response function.

B. Extracting the Benthic Mixing Impulse Response Function: a
Constrained Deconvolution Technique

Abstract (Chapter 4 of the dissertation):

Benthic mixing or bioturbation acts as a low-pass filter on stratigraphic signals, altering both the apparent rates and amplitudes of recorded events. The mixing process is represented as a time-invariant convolution, and uses an impulse response function (IRF) parameterized in terms of mixed layer thickness and mixing intensity (diffusion coefficient). Such parameterization facilitates construction of the inverse (deconvolution) model, which is used to examine the effects of incorrect IRF characterization on deconvolution results. Results show that mixing intensity is as important a parameter as mixed layer thickness when unmixing a stratigraphic signal.

Stable oxygen isotope records from two different species of planktonic foraminifers with changing relative abundances in the same core will show apparent offsets in the timing of events due to mixing (Hutson, 1980). The offset can be used, with the appropriate unmixing equation, to constrain mixed layer thickness and mixing intensity based on analysis of actual isotope signals. The assumption is that any offsets in the records of the two species are totally a product of the mixing process.

The technique was applied to a high-resolution glacial-

interglacial record (Termination II) from an equatorial Pacific piston core. Multiple lateral subsamples were stacked to increase signal to noise ratio. A multidimensional nonlinear optimization routine (SIMPLEX) was used to minimize an error function related to stratigraphic offsets between the two species. A solution to this problem yielded a mixed layer 5 cm thick and a mixing intensity of $7 \text{ cm}^2/\text{ka}$. This mixed layer thickness is at the low end of estimates based on ^{14}C profiles in box cores from the same geographic area (Berger and Killingley, 1982). The mixing operator is probably conservative, and does not take into account that sedimentation rates were higher during the last glacial period than during the Holocene. This may explain the inability of the algorithm to completely remove the stratigraphic offset between the two isotope records. The unmixed record (using the parameters 5 cm and $7 \text{ cm}^2/\text{ka}$) shows a deglaciation overshoot which is distinctly smaller than the "meltwater spike" proposed by Berger et al. (1977), i.e., less than 0.1 ‰ versus a range of 0.3 ‰ to 1 ‰ .

1. Program HUTSON: This program performs a benthic mixing (convolution) operation on an input stable isotope signal. The mixing takes into consideration the change in relative abundance of the isotope carrier (foraminifer species) as described in Hutson (1980). The user is asked for input file-names for isotopes, abundances and the mixing operator. The mixed record is stored in a user-specified file.
2. Program DECOTEST: This program is a simple driver for time-domain deconvolution of a stable isotope signal. The user is asked for the isotope record infile, the mixing function infile, and a constant that controls the sensitivity of the unmixing. Values between 0.001 and 0.05 were found appropriate for most real and simulated isotope signals, with larger numbers giving less sensitivity. The program accesses subroutine DECO, which performs the deconvolution. The unmixed record is stored in a user-specified file.
3. Program HUTDEC: This program is the inverse of program HUTSON. Like DECOTEST, this routine deconvolves an isotope signal, but the relative abundance of the signal carrier is also considered in HUTDEC. The program operates as described for DECOTEST above.
4. Program OFFSET: This is a large and relatively complicated driver program that attempts to remove stratigraphic offset between two stable isotope signals from different foraminifer species in a single core by deconvolving the signals with various unmixing functions. (Refer to the thesis for details.) The heart of the driver is a simplex optimization

algorithm (Nelder and Mead, 1965) modified from Daniels (1978). The fit of the two unmixed curves is optimized by adjusting the benthic mixing parameters. The program examines stratigraphic offset by calling subroutine ERROR, which, by calling GSIRF and DECO, unmixes the two signals and examines closeness of fit.

5. Subroutine ERROR: This algorithm calculates a value for the optimization error function as described for OFFSET. This is a specialized subroutine which accepts two isotope signals (different foraminifer species from the same core) their relative abundances, and the benthic mixing parameters. Four calls to DECO unmixes the records and calculates the residual between the two unmixed signals (error function).
6. Subroutine DECO: This algorithm performs a time-domain deconvolution of a measured or theoretical stable isotope signal. The subroutine is accessed by a statement:

```
CALL DECO [IRF vector, number of points in  
input, input vector, output vector, decon-  
volution sensitivity].
```

DECOTEST is a simple driver program for using this subroutine.

7. Subroutine CNVLV: This subroutine convolves two vectors and stores the result in a third. The input arrays have lengths N and M, with the output of length $N + M - 1$.
8. Subroutine ZERO: This algorithm sets the mean value of a vector to zero. The original mean value is saved as AMEAN.

C. Bruhnes Dissolution Cycle: Effects on Oxygen Isotopes, Sedimentation Rates, and Signal Spectra

Abstract (Chapter 5 of the dissertation):

A long wavelength cycle (400-500 ka) has been found in stable oxygen isotope records from Pleistocene deep-sea sediments in the Pacific Ocean. This cycle shows an increase in amplitude with increasing water depth, correlates in both phase and duration with the Brunhes dissolution cycle of Adelseck (1980) and is apparently a result of differential dissolution. This dissolution cycle has significantly affected sedimentation rates, particularly in deep water sediments. Sediment loss through dissolution can be quantified by comparing isotope stage lengths with some shallow reference core or by using $\%CaCO_3$ data. Examination of a number of equatorial Pacific cores suggests that even sediments recovered from a water depth of 3500 m have undergone significant distortion as a result of this dissolution. Long-wavelength sedimentation rate perturbation results in a widening of spectral peaks, with a consequent decrease of spectral resolution, if some depth scale correction is not made.

The Brunhes dissolution cycle is apparently one of many cycles which continue with a periodicity of roughly 400 ka back into the Miocene. Dissolution on this time scale resembles the orbital eccentricity record, which has strong 100 and 400 ka components. The fact that the 400 ka cycle is

not seen in shallow water oxygen isotope records suggests that it is not directly related to ice volume, but rather to some element of the carbon cycle affecting carbonate understaturation in the deep ocean.

1. Program DISSOLVE: This program accepts two stable oxygen isotope stratigraphies and their isotope stage boundary positions, aligns the second signal to the first using the isotope stage boundaries, and subtracts the second curve from the first. Interpolation is done with cubic splines (de Boor, 1978). The residual curve is then smoothed and stored in a user-specified file.
2. Program ANALPOW: This program computes the power spectrum of a stratigraphic signal. A matrix of downcore measurements and depths are read in, equally spaced with cubic spline interpolation, windowed and Fourier transformed. The raw spectrum is band averaged (see Otnes and Enochson, 1972) and converted to relative decibels.

D. Spectral Effects of Time-Depth Nonlinearities in Deep Sea
Sediment Records: A Demodulation Technique for Realigning
Time and Depth Scales

Abstract (Chapter 7 of the dissertation):

^{14}C dating and $\%\text{CaCO}_3$ in late Pleistocene sediments suggest that deep-sea sedimentation rates vary cyclically and that this cyclicity is related to climate. Sedimentation rate variability leads to nonlinearity in the time-depth mapping function. This nonlinearity can have profound effects on signal spectra, leading to the development of harmonics and intermodulation tones. These distortion effects in the spectra give a direct indication of the degree of nonlinearity, thereby providing a tool for realigning time and depth scales. A tuning technique is developed which assumes a direct link between climate (as measured in $\delta^{18}\text{O}$ from planktonic foraminifer tests) and sedimentation rates. A criterion of "spectral simplicity", as quantified in the varimax norm, is used to demodulate the input spectrum. Application of this technique to an equatorial Pacific piston core (ERDC 84) found peak glacial sedimentation rates to be 30% higher than peak interglacial rates, a figure in good agreement with ^{14}C -based estimates from the same area. This technique is compatible with other time-scale tuning techniques such as those using orbital parameters, and, in

combination with these other techniques, provides a method for fine-tuning any late Pleistocene record.

1. Program WAVETEST: This program examines the effects of systematic depth-scale perturbation on signal spectra. A sinusoidal signal is generated by calling WAVGEN. The program then adjusts depth values according to signal amplitude, interpolates with cubic splines for equal sample spacing, and calculates the power spectrum. A range of degrees of signal distortion are examined via a DO loop and the results in both time and frequency domains are stored in a user-specified file.
2. Program ISOJUST: This program is essentially the same as WAVETEST except that it uses measured isotope data as input rather than calling for a sinusoidal signal. The input signal is progressively distorted via a DO loop, and the power spectrum is calculated at each step. The spectra are band averaged and a varimax norm is calculated for each spectrum to determine its simplicity. Isotope stage boundaries are read in, which are used to quantify the signal distortion.
3. Program VARIMAX: This simple program calculates a varimax norm as described by Wiggins (1978) for quantifying the simplicity of a signal. The program accepts a vector as input.
4. Subroutine WAVGEN: This algorithm generates a multi-component sinusoidal time series of length NS. The component wavelengths are specified within the subroutine.

III. Program Listings


```

600 DO 50 I=1,NPTS
610 PEAK=MAX(PEAK,REAL(WORKOUT(I)))
620 DO 51 I=1,NPTS
630 IF (REAL(WORKOUT(I)).EQ.0.) THEN
640 WORKOUT(I)=CMPLX(-100.,0.)
650 GO TO 51
660 ELSE
670 WORKOUT(I)=CMPLX(10.*ALOG10(REAL(WORKOUT(I))/PEAK),0.)
680 ENL IF
C 51 CONTINUE
690 OUTPUT RESULTS
700 MP=(MOPNT/2)+1
710 CALL REALFART(DATA,WORKOUT,NPTS)
720 DO 45 I=1,(MP-1)
730 AI=1
740 AK=(AI/(MOPNT*XINT))
750 LOUT(I,1)=AK
760 IF (DATA(I+4).GT.-40.) GO TO 90
770 DATA(I+4)=-40.0
780 LOUT(I,2)=DATA(I+4)
790 WRITE(16,46) (LOUT(I,J),J=1,2)
800 45 FORMAT(1X,2G15.7)
810 STOP
820 ENL

```

```

C      PROGRAM IFCOTEST: TIME-DOMAIN DECONVOLUTION WITH IECC
C      DIMENSION XISC(103),H(64)
C      DIMENSION XCUT(166)
C      CHARACTER*20 INFILE1,INFILE3
C      CHARACTER*20 CUTFILE1
C      -----
C      WRITE(6,1)
1      FORMAT(2) NUMBER OF SAMPLES IN INPUT ISOTOPE STRING:13
2      READ(5,2) NPTS
2      FCFORMAT(13)
3      WRITE(6,3)
3      FORMAT(2) WHAT IS THE ISOTOPE INFILE?
4      READ(5,4) INFILE1
4      FCFORMAT(A)
4      OPEN(UNIT=15,NAME=INFILE1,STATUS='OLD')
4      MPTS=64
4      DO 100 I=1,64
100  H(I)=2.0
11      WRITE(6,11)
11      FCFORMAT(2) WHAT IS THE ISOTOPE OUTFILE?
11      READ(5,4) OUTFILE1
11      OPEN(UNIT=16,NAME=OUTFILE1,STATUS='NEW')
12      WRITE(6,12)
12      FCFORMAT(2) WHAT IS THE IECC GAIN LIMIT? :F17.9
13      READ(5,13) GAIN
13      FCFORMAT(F17.9)
C      -----
C      IMPLUSE RESPONSE FUNCTION
52      WRITE(6,52)
52      FCFORMAT(2) WHAT IS THE IIR INFILE?
52      READ(5,4) INFILE3
52      OPEN(UNIT=35,NAME=INFILE3,STATUS='OLD')
51      DO 51 I=1,64
51      READ(35,3) INDATA
51      DO 22 I=1,NPTS
22      READ(15,*) XISC(I)
22      H(I)=NPTS-I
22      CALL IECC(H,MPTS,XISC,XOUT,GAIN)
34      DO 34 I=1,NPTS
34      WRITE(16,34) XOUT(I)
34      FCFORMAT(G17.5)
34      STOP
END

```

```

C      PROGRAM LISSCIVE
C      PROGRAM ADJUSTS TWO STRATIGRAPHIES ABOUT INPUT CONTROL TIES
C      AND CALCULATES THE RESIDUAL.
C      DIMENSION XXX1(200),XXX2(200),XXD1(200),XXD2(200)
C      DIMENSION STG1(30),STG2(30),FACTOR(30),H(10)
C      DIMENSION XRESID(200),XIS01(200),XIS02(200),XOUT(200)
C      CHARACTER*20 INFILE1,INFILE2
C      CHARACTER*20 OUTFILE
C
C      -----
C      WRITE(6,1)
C      1  FORMAT('  FILENAME FOR FIRST CORE? ')
C      READ(5,2) INFILE1
C      2  FORMAT('  ')
C      OPEN(UNIT=14,NAME=INFILE1,STATUS='OLD')
C      WRITE(6,3)
C      3  FORMAT('  HOW MANY SAMPLES IN THE FIRST DATA SEQUENCE: I3 ? ')
C      READ(5,4) NS1
C      4  FORMAT('  ')
C      DO 7 I=1,NS1
C      7  READ(14,99) XXD1(I),XXX1(I)
C      CALL ZERO(XXX1,NS1,AMEAN1)
C      99  FORMAT('  5X,F5.0,3X,F5.2')
C      WRITE(6,5)
C      5  FORMAT('  HOW MANY STAGE BOUNDARIES 7: I2 ')
C      READ(5,6) NSTG
C      6  FORMAT('  ')
C      WRITE(6,10)
C      10  FORMAT('  INPUT STAGE BOUNDARIES IN CM ')
C      DO 11 I=1,NSTG
C      11  READ(5,*) STG1(I)
C      -----
C      WRITE(6,12)
C      12  FORMAT('  FILENAME FOR THE SECOND CORE? ')
C      READ(5,2) INFILE2
C      OPEN(UNIT=15,NAME=INFILE2,STATUS='OLD')
C      WRITE(6,13)
C      13  FORMAT('  HOW MANY SAMPLES IN THE DATA SEQUENCE? : I3 ')
C      READ(5,4) NS2
C      DO 15 I=1,NS2
C      15  READ(15,199) XXD2(I),XXX2(I)
C      CALL ZERO(XXX2,NS2,AMEAN2)
C      199  FORMAT('  4X,F4.0,F5.2')
C      WRITE(6,16)
C      16  FORMAT('  INPUT STAGE BOUNDARIES IN CM ')
C      DO 17 I=1,NSTG
C      17  READ(5,*) STG2(I)
C      WRITE(6,70)
C      70  FORMAT('  STAGE BOUNDARIES AND MULTIPLICATIVE FACTORS ')
C      DO 71 I=2,NSTG
C      71  FACTOR(I)=(STG1(I)-STG1(I-1))/(STG2(I)-STG2(I-1))
C      DO 73 I=1,NSTG
C      73  WRITE(6,72) I,STG1(I),STG2(I),FACTOR(I)
C      72  FORMAT('  15,3F15.5')
C      -----
C      WRITE(6,30)
C      30  FORMAT('  WHAT IS THE OUTPUT FILE ? ')
C      READ(6,2) OUTFILE

```

```

C      OPEN (UNIT=16,NAME=OUTFILE,STATUS='NEW')
C      STANLARIZE SAMPLE SPACING IN CORE#1: 10CM INTERVALS
C      GENERATE A NEW DEPTH SCALE
NPOINT=XXD1(NS1)/10.
WRITE(6,49) NPOINT
49  FORMAT(' NPOINT= ',I3)
      XD(1)=0.0
      DO 25 I=2,NPOINT
25  XD(I)=XD(I-1)+10.0
      CALL INTERPOLATE(XXX1,XXL1,XISO1,XT,WORK,NS1,NPOINT,IBAD,NF,NI)
C      REFERENCE ISOTOPES ARE IN (XI,XISO1); SECOND SEQUENCE IS IN
      (XXD2,XXX2). NEW DEPTH VALUES FOR CORE#2 ARE PUT IN XNEW.
      J=1
      XNEW(1)=0.0
      DO 100 I=2,NS2
      WRITE(6,42) I,XXD2(I)
      IF (XXD2(I).LE.STG2(J)) GO TO 110
      WRITE(6,43)
43  FORMAT(' NEXT J ')
      J=J+1
110  XNEW(I)=XNEW(I-1)+(XXD2(I)-XXD2(I-1))*FACTOR(J)
      WRITE(6,42) I,XNEW(I)
42  FORMAT('1E,10X,F10.5')
100  CONTINUE
C      INTERPOLATE Y VALUES FOR NEW DEPTHS
C      CALL INTERPOLATE(XXX2,XNF,XISO2,XT,WORK,NS2,NPOINT,IBAD,NF,NI)
C      CALCULATE RESIDUAL AND PLACE IN XRESII.
      DO 200 I=1,NPOINT
200  XRESII(I)=XISC1(I)-XISC2(I)
C      SMOOTH THE RESIDUAL CURVE
      MPIS=5
      H(1)=0.11111
      H(2)=0.22222
      H(3)=0.33333
      H(4)=0.22222
      H(5)=0.11111
      CALL CRVIV(XRESII,H,XOUT,NPOINT,MPIS)
      NPIS=NPPOINT+MPIS-1
      DO 201 I=1,NPIS
201  WRITE(16,202) XD(I),XOUT(I)
202  FORMAT('F10.1,10X,F10.5')
      STOP
      END

```



```

C PROGRAM HUTTEC: DECONVOLUTION WITH SIGNAL CARRIER ABUNDANCE
C DIMENSION XISO(103),POP(103),H(64)
C DIMENSION A1(103),A2(166),A3(166),A4(166),A5(166)
C CHARACTER*20 INFILE1,INFILE2,INFILE3
C CHARACTER*20 OUTFILE1
-----
1 WRITE(6,1)
2 FORMAT(2) NUMBER OF SAMPLES IN INPUT ISOTOPE STRING?:13 ')
3 READ(5,2) NPPTS
4 WRITE(6,3)
5 FORMAT(13)
6 WRITE(6,3)
7 FORMAT(13)
8 WHAT IS THE ISOTOPE INFILE? ')
9 READ(5,4) INFILE1
10 FORMAT(4)
11 OPEN(UNIT=15,NAME=INFILE1,STATUS='OLD')
12 WRITE(6,5)
13 FORMAT(5)
14 WHAT IS THE ABUNDANCE INFILE? ')
15 READ(5,4) INFILE2
16 OPEN(UNIT=25,NAME=INFILE2,STATUS='OLD')
17 MPTS=64
18 DO 100 I=1,64
19 H(I)=0.0
20 WRITE(6,11)
21 FORMAT(11)
22 WHAT IS THE ISOTOPE OUTFILE? ')
23 READ(5,4) OUTFILE1
24 OPEN(UNIT=16,NAME=OUTFILE1,STATUS='NEW')
25 WRITE(6,12)
26 FORMAT(12)
27 WHAT IS THE DECON GAIN LIMIT? :F10.9 ')
28 READ(5,13) GAIN
29 FORMAT(13)
30 -----
31 INPUT RESPONSE FUNCTION
32 WRITE(6,50)
33 FORMAT(50)
34 WHAT IS THE IRF INFILE? ')
35 READ(5,4) INFILE3
36 OPEN(UNIT=35,NAME=INFILE3,STATUS='OLD')
37 DO 51 I=1,64
38 READ(35,*) H(I)
39 READ IN DATA
40 DO 20 I=1, NPPTS
41 READ(15,*) XISO(I)
42 FORMAT(6X,F5.2)
43 DO 22 I=1, NPPTS
44 READ(25,*) POP(I)
45 DO 25 I=1, NPPTS
46 A1(I)=XISO(I)*PCP(I)
47 NP=NPPTS+MPTS-1
48 CALL FFCO(E,NPPTS,POP,A4,GAIN)
49 CALL FFCO(H,NPPTS,A1,A2,GAIN)
50 DO 27 I=1, NP
51 WRITE(6,26) A2(I)
52 DO 28 I=1, NP
53 WRITE(6,26) A4(I)
54 DO 34 I=1, NP
55 IF (A4(I).EQ.0.0) GO TO 40
56 A3(I)=A2(I)/A4(I)
57 GO TO 33
58 A5(I)=0.0
59 CONTINUE
60 WRITE(16,26) A5(I)
61 FORMAT(16,26)
62 STOP
63 END

```

```

C PROGRAM HUTSON: CONVOLUTION WITH SIGNAL CARRIER ABUNDANCE
C DIMENSION XISC(50),POF(50),E(64)
C DIMENSION A1(50),A2(150),A3(150),A4(150),A5(150)
C CHARACTER*20 INFILE1,INFILE2,INFILE3
C CHARACTER*20 OUTFILE1
-----
C WRITE(6,1)
1 FORMAT(1,NUMBER OF SAMPLES IN INPUT ISOTOPE STRING?:12 ')
C READ(5,2) NPTS
2 FORMAT(1,12)
C WRITE(6,3)
3 FORMAT(1,WHAT IS THE ISOTOPE INFILE? ')
C READ(5,4) INFILE1
4 FORMAT(1,A)
C OPEN(UNIT=15,NAME=INFILE1,STATUS='OLD')
C WRITE(6,5)
5 FORMAT(1,WHAT IS THE ABUNDANCE INFILE? ')
C READ(5,4) INFILE2
C OPEN(UNIT=25,NAME=INFILE2,STATUS='OLD')
C MPTS=64
C DO 100 I=1,64
100 H(I)=0.0
C WRITE(6,11)
11 FORMAT(1,WHAT IS THE ISOTOPE OUTFILE? ')
C READ(5,4) OUTFILE1
C OPEN(UNIT=16,NAME=OUTFILE1,STATUS='NEW')
-----
C IMPULSE RESPONSE FUNCTION
C WRITE(6,52)
50 FORMAT(1,WHAT IS THE IEF INFILE? ')
C READ(5,4) INFILE3
C OPEN(UNIT=35,NAME=INFILE3,STATUS='OLD')
C DO 51 I=1,64
51 H(I)=0.0
C READ IN DATA
C DO 20 I=1,NPTS
20 H(I)=XISC(I)
C DO 22 I=1,NPTS
22 H(I)=POF(I)
C DO 25 I=1,NPTS
25 A1(I)=XISC(I)*PCP(I)
C NF=NPTS+MPTS-1
C CALL CNVIV(POF,F,A4,NPTS,MPTS)
C CALL CNVIV(A1,H,A2,NPTS,NPTS)
C DO 34 I=1,NP
34 IF (A4(I).EQ.0.0) GO TO 40
C A5(I)=A2(I)/A4(I)
C GO TO 33
40 A5(I)=0.0
C CONTINUE
C WRITE(6,26) A5(I)
26 FORMAT(1,12,26)
C STOP
C ENI

```

```

C      PROGRAM ISOJUST (ISOTOPE ADJUST)
C-----
C      PROGRAM RECALCULATES ISOTOPES WITH DEPTH/TIME ADJUSTMENTS BASED
C      ON SEDIMENTATION RATE CHANGES. DEPTH SCALE IS MODIFIED LINEARLY
C      ACCORDING TO SIGNAL MAGNITUDE.
C-----
C      DIMENSION XXX(500,2), P(500), BUF(500), DATA(500)
C      DIMENSION XNEW(500), XN1(500), XN2(500,2), COUT(500,2), DOUT(500,2)
C      DIMENSION XISO(500), XISO2(500), DEPTH1(500), DEPTH2(500)
C      DIMENSION XN3(500), XN4(500), WORK(1500), STG(20), XSTG(20)
C      COMPLEX CWORK(500), WORKOUT(500), CE(10)
C      CHARACTER*20 INFILE
C      CHARACTER*20 OUTFILE
C-----
C      WRITE(6,80)
C      80  FORMAT(' INPUT NUMBER OF SAMPLES IN THE DATA SEQUENCE: I3 ')
C      1202 READ(5,1200) NS
C      1200  FORMAT(' I3 ')
C      51  WRITE(6,51)
C      51  FORMAT(' WHAT IS THE INPUT FILE NAME? ')
C      51  READ(5,41) INFILE
C      51  OPEN(UNIT=15, NAME=INFILE, STATUS='OLD')
C      44  WRITE(6,40)
C      44  FORMAT(' WHAT IS THE OUTPUT FILE NAME? ')
C      41  READ(5,41) OUTFILE
C      41  OPEN(UNIT=16, NAME=OUTFILE, STATUS='NEW')
C      125  WRITE(6,125)
C      125  FORMAT(' NUMBER OF ISOTOPE STAGES IN SERIES? : I3 ')
C      126  READ(5,126) NISO
C      126  FORMAT(' I3 ')
C      127  WRITE(6,127)
C      127  FORMAT(' CORE DEPTHS OF ISOTOPE STAGE BOUNDARIES? : 20F4.0 ')
C      128  READ(5,128) (STG(I), I=1, NISO)
C      128  FORMAT(' 20F4.0 ')
C-----
C      REAL DATA INTO XXX
C      DO I=1, NS
C      52  READ(5,52) (XXX(I,J), J=1,2)
C      52  FORMAT(' 5X, F4.0, 4X, F5.2 ')
C      NPNTS=((XXX(NS,1))/10)+1)
C      52  WRITE(6,52) NPNTS
C      52  FORMAT(' NPNTS= I4 ')
C      INTERPOLATE DATA INTO 10CM INTERVALS
C      DO I=1, NS
C      50  DEPTH1(I)=XXX(I,1)
C      50  XISO(I)=XXX(I,2)
C      CALL RANGE(XISO, NS, DMAX, DMIN, DX)
C      501  WRITE(6,501) DX
C      501  FORMAT(' DX= F5.7 ')
C      DO I=1, NPNTS
C      56  DEPTH2(I)=(I-1)*10
C      CALL INTERPOLATE(XISO, DEPTH1, XISO2, DEPTH2, CWORK, NS, NPNTS, IBAD, NF, NL)
C      NPNTS=NL-NF+1
C      91  WRITE(6,91) NPNTS
C      91  FORMAT(' NPNTS= I4 ')
C      ZERO MEAN DATA
C      CALL ZERO(XISO2, NPNTS, AMEAN)
C      DEPTH ADJUSTMENT

```

```

DO 79 J=1,72
FACTR=(J-1)/50.0)
CCOUNT=0.0
XNEW(1)=0.0
DC 73 I=2,NPTS
TERM=(2*(FACTR)*(ABS(XISO(I))))/IX
IF (XISO2(I)) 71,71,62
62 XNEW(I)=COUNT+(10.0)*(1.-TERM)
CCOUNT=XNEW(I)
GC TC 73
71 XNEW(I)=COUNT+(10.0)*(1.+TERM)
CCOUNT=XNEW(I)
73 CCOUNTINUE
WRITE(6,150)
150 FORMAT(' DETERMINE EFFECTIVE SEDIMENTATION DIFFERENTIALS ')
L=1
DO 112 I=1,NPTS
IF (LEFT2(I)-STG(I)) 110,111,111
111 XSTG(I)=XNEW(I)
L=L+1
IF (L.GT.NISO) GO TO 750
112 CCOUNTINUE
732 CONTINUE
C WRITE(6,112) ADJUSTED ISOTOPE STAGE BOUNDARIES
112 FORMAT(' ADJUSTED ISOTOPE STAGE BOUNDARIES ')
DO 113 I=1,NISO
113 WRITE(6,114) I,XSTG(I)
114 FORMAT(' I,XSTG(I) ')
C EFFECTIVE FACTOR = (LENGTH OF ADJUSTED STAGE)/(LENGTH OF INPUT STAGE)
116 WRITE(6,116) EFFECTIVE SEDIMENTATION RATE FACTORS
116 FORMAT(' EFFECTIVE SEDIMENTATION RATE FACTORS ')
I=1
FFACT=((XSTG(I))/(STG(I)))
117 WRITE(6,117) I,FFACT
117 FORMAT(' ISOTOPE STAGE = '.I3.' FACTOR = '.F5.2)
DO 118 I=2,NISO
FFACT=((XSTG(I)-XSTG(I-1))/(STG(I)-STG(I-1)))
118 WRITE(6,117) I,FFACT
333 CCOUNTINUE
C SQUEEZE OR STRETCH XNEW TO SAME LENGTH AS XISO2. (=NPTS)
NF=((XNEW(NPTS))/10)+1)
12 WRITE(6,12) NF
12 FORMAT(' NUMBER OF POINTS = ',I4)
ANPTS=NPTS
ANP=NF
DO 11 I=1,NPTS
11 XN1(I)=(XNEW(I)*(ANPTS/ANP))
INTERPOLATION: CUBIC SPLINE
XN1(I) AND XISO2(I) ARE USED AS INPUT. WITH THE NEW LEPTH SCALE
SPECIFIED AS XN3, OF LENGTH NPTS
RECALCULATE ISOTOPES ARE CONTAINED IN XN4.
LEPTH=0
XN3(1)=LEPTH
DO 33 I=2,NPTS
33 DEPTH=DEPTH+10.0
XN3(I)=DEPTH
CALL INTERPOLATE(XISO2,XN1,XN4,XN3,WORK,NPTS,NPTS,IBAD,NF,NL)
NOPNT=NL-NF+1

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```

122 WRITE(6,60) NOPNT
123 FC=FORMAT('NUMBER OF FCINTS ARE = ',I3)
C 62 STORE DATA
DO 102 I=1,NOPNT
120 COUT(I,1)=(I-1)*10
121 COUT(I,2)=XN4(I)+A*FEAN
122 WRITE(16,101) (COUT(I,K),K=1,2)
121 FORMAT(1X,2G15.7)
850 CONTINUE
C ANALYSIS OF DATA
CALL CLEAR(CWORK,500)
C TRANSFER DATA INTO WORK AREA
CALL COMPLEX(XN4,CWORK,NOPNT)
C ZERO MEAN AND DETREND (IF NECESSARY) THE DATA
CALL ZEROMEAN(CWORK,NOPNT)
C *INFORM THE DATA
CALL PROLATE(CWORK,NOPNT,0)
C COMPUTE THE FOURIER TRANSFORM
MOPNT=IBINARY(NOPNT)
CALL FFT(CWORK,NOPNT,MOPNT)
CALL POWER(CWORK,MOPNT)
C BAND AVERAGING
CH(1)=CMPLX(0.25,0.)
CH(2)=CMPLX(0.5,0.)
CH(3)=CMPLX(0.25,0.)
C CALL CCNVLV(CWORK,CH,WORKOUT,MOPNT,3)
C CONVERT TO RELATIVE DECIBELS
PEAK=-1.0E+38
DO 190 I=1,MOPNT+2
190 PEAK=MAX(PEAK,REAL(WORKOUT(I)))
DO 191 I=1,MOPNT+2
IF (REAL(WORKOUT(I)).EQ.0.) THEN
WORKOUT(I)=CMPLX(-100.,2.)
GO TO 191
ELSE
WORKOUT(I)=CMPLX(10.*ALOG10(REAL(WORKOUT(I))/PEAK),0.)
END IF
C 191 CONTINUE
C OUTPUT RESULTS
MP=(MOPNT/2)
CALL REALPART(DATA,WORKOUT,MOPNT+2)
DO 45 I=2,MP+1
AI=I-1
AK=AI/(MOPNT*10.)
IF (DATA(I+1).GT.-25.) GO TO 45
DATA(I+1)=-25.
45 WRITE(16,47) AK,DATA(I+1)
47 FORMAT(5X,G15.7,5X,G17.5)
C VARIANCE CALCULATION
V1=0.0
V2=0.0
V=0.0
DO 95 I=3,MP+2
V1=V1+(DATA(I)**4)
V2=V2+(DATA(I)**2)
95 CONTINUE
V=V1/(V2**2)
WRITE(6,46) J-1,V
46 FORMAT(5X,12,5X,G15.7)

```



```

C      PROGRAM OFFSET: SIMPLEX DECONVOLUTION
C      SIMPLEX OPTIMIZATION OF DANIELS, 1978, MODIFIED
C      TO OPTIMIZE THE FIT OF TWO UNFIXED ISOTOPIC SIGNALS.
C      DIMENSION C(2), ERR(3), P(3,3), R(2), X(2)
C      DIMENSION XISC1(100), XISO2(100), POP1(100), POP2(100), W(100)
C      DIMENSION FW1(100), FW2(100), PW1(100), PW2(100), OUT1(128)
C      DIMENSION CUT3(128)
C      INTEGER H
C      CHARACTER*20 INFILE1, INFILE2, INFILE3, INFILE4, INFILE5
C      CHARACTER*20 OUTFILE
C      -----
C      WRITE(6,200)
C      200 FORMAT('HOW MANY DATA POINTS: I2 ? ')
C      READ(5,201) NP
C      201 FORMAT(I2)
C      READ IN DATA FILES
C      WRITE(6,202)
C      202 FORMAT('ISO1 FILENAME ? ')
C      READ(5,203) INFILE1
C      203 FORMAT(A)
C      OPEN(UNIT=15, NAME=INFILE1, STATUS='OLD')
C      204 DO 1=1, NP
C      READ(15,205) XISO1(I)
C      CALL ZERC(XISC1, NP, AMFAN1)
C      DO 888 I=1, NP
C      888 XISO1(I)=XISO1(I)*0.87
C      205 WRITE(6,206)
C      206 FORMAT('ISO2 INFILE ? ')
C      READ(5,203) INFILE2
C      OPEN(UNIT=17, NAME=INFILE2, STATUS='OLD')
C      DO 207 I=1, NP
C      207 READ(17,205) XISC2(I)
C      CALL ZFRO(XISC2, NP, AMFAN2)
C      WRITE(6,208)
C      208 FORMAT('POP1 FILENAME ? ')
C      READ(5,223) INFILE3
C      OPEN(UNIT=18, NAME=INFILE3, STATUS='OLD')
C      DO 209 I=1, NP
C      209 READ(18,205) POP1(I)
C      WRITE(6,210)
C      210 FORMAT('POP2 FILENAME ? ')
C      READ(5,203) INFILE4
C      OPEN(UNIT=19, NAME=INFILE4, STATUS='OLD')
C      DO 211 I=1, NP
C      211 READ(19,205) POP2(I)
C      WRITE(6,212)
C      212 FORMAT('WEIGHT FILENAME ? ')
C      READ(5,203) INFILE5
C      OPEN(UNIT=20, NAME=INFILE5, STATUS='OLD')
C      DO 213 I=1, NP
C      213 READ(20,205) W(I)
C      -----
C      CALCULATE POPULATION CHANGES
C      DO 220 I=1, NP
C      PW1(I)=POP1(I)*W(I)
C      PW2(I)=POP2(I)*W(I)
C      PW11(I)=PW1(I)*XISO1(I)
C      220 PW12(I)=PW2(I)*XISO2(I)

```

```

C      READ IN INITIAL VALUES
C      WRITE(6,10)
10     FORMAT('WHAT ARE THE INITIAL VALUES:DEF,DIF:2F5.2? ')
11     READ(5,11) X(1),X(2)
12     WRITE(6,12) X(1),X(2)
13     FORMAT('WHAT IS THE SEI RATE:F4.1 ? ')
14     READ(5,14) GAIN
15     WRITE(6,15) GAIN
16     FORMAT('WHAT IS THE DECON GAIN LIMITATION:F10.9 ? ')
17     READ(5,17) GAIN
18     WRITE(6,18) GAIN
19     CALL FRROR(X,E,V,PW11,PW12,PW1,PW2,GAIN,NP,OUT1,OUT3)
20     WRITE(6,12) X(1),X(2),E
21     FORMAT('DEP= .F10.5,5X.' DIF= .F10.5,5X.' E= .F10.5)
C      INITIALIZE SIMPLEX
C      DO 22 J=1,2
22     P(1,J)=X(J)
23     DO 24 I=1,3
24     P(I,J)=X(J)
25     IF (ABS(X(I-1))-1.1E-12) P(I,I-1)=0.0001
26     CRITER FCINTE ACCORDING TO VALUES OF FRROR
27     I=1
28     H=1
29     DO 30 J=1,3
30     X(J)=F(1,J)
31     CALL FRROR(X,E,V,PW11,PW12,PW1,PW2,GAIN,NP,OUT1,OUT3)
32     FRR(I)=F(1,J)
33     IF (ERR(I).LT.ERR(H)) I=I
34     IF (ERR(I).GT.ERR(H)) H=I
35     NE=I
36     DO 43 I=1,3
43     IF (ERR(I).GE.ERR(NE).AND.I.NE.H) NH=I
C      CALCULATE CENTROID (AVERAGE)
44     DO 50 J=1,2
50     C(J)=-P(F,J)
51     DO 54 I=1,3
54     C(J)=C(J)+F(I,J)
55     C(J)=C(J)/2
56     WRITE(6,56)
57     FORMAT('REFLECT ABOUT THE CENTROID')
58     DO 62 J=1,2
62     R(J)=1.00005*C(J)-0.9985*P(H,J)
63     CALL FRROR(R,E,V,PW11,PW12,PW1,PW2,GAIN,NP,OUT1,OUT3)
64     WRITE(6,12) R(1),R(2),E
65     REFLECT AGAIN (IF MODERATELY SUCCESSFUL)
66     IF (ERR(I).LT.ERR(H)) GO TO 51
67     IF (ERR(I).GE.ERR(H)) GO TO 122
68     DO 60 J=1,2
60     P(H,J)=R(J)
69     FRR(I)=R(J)
70     IF (ERR(I).GE.ERR(NH)) GO TO 61

```

```

1190 H=NH
1200 GO TO 41
1210
1220 C
1230 91 L=H
1240 503 WRITE(6,503)
1250 FORMAT(' EXPAND THE SIMPLEX ')
1260 E=NE
1270 DC 93 J=1,2
1280 93 X(J)=1.05*R(J)-0.95*C(J)
1290 CALL ERROR(X,EX,V,FWI1,FWI2,PW1,PW2,GAIN,NP,OUT1,OUT3)
1300 WRITE(6,12) X(1),X(2),EX
1310 IF(EX.LT.FR) GO TO 104
1320 DO 99 J=1,2
1330 99 P(L,J)=R(J)
1340 ERR(L)=FR
1350 GO TO 110
1360 DO 105 J=1,2
1370 105 P(L,J)=X(J)
1380 ERR(L)=EX
1390 110 WRITE(6,12) P(L,1),P(L,2),ERR(L)
1400 WRITE(6,111)
1410 111 FORMAT(' DO YOU WISH TO CONTINUE? YES=1,NO=0 ')
1420 READ(5,112) IFI
1430 112 FORMAT('11')
1440 IF(IFI.EQ.1) GO TO 41
1450 GO TO 150
1460
1470 C
1480 122 WRITE(6,504)
1490 504 FORMAT(' CONTRACT THE SIMPLEX ')
1500 DO 123 J=1,2
1510 123 R(J)=0.55*C(J)+0.45*P(L,J)
1520 CALL ERROR(R,ER,V,FWI1,FWI2,PW1,PW2,GAIN,NP,OUT1,OUT3)
1530 WRITE(6,12) R(1),R(2),ER
1540 IF(ER.LT.FR) GO TO 79
1550 IF(ER.LT.ERR(L)) GO TO 79
1560 C
1570 SCALE THE SIMPLEX: SK IS THE SCALING FUNCTION
1580 WRITE(6,132)
1590 130 FORMAT(' WHAT IS THE SIMPLEX SCALING FACTOR:F4.1 ? ')
1600 READ(5,131) SK
1610 131 FORMAT('F4.1')
1620 DO 133 J=1,2
1630 133 P(L,J)=P(L,J)+SK*(P(L,J)-R(J))
1640 GO TO 31
1650 CONTINUE
1660 151 WRITE(6,151)
1670 151 FORMAT(' WHAT IS THE OUTFILE ? ')
1680 READ(5,203) OUTFILE
1690 OPEN(UNIT=16,NAME=OUTFILE,STATUS='NEW')
1700 NPTS=NP+64-1
1710 A=(NPTS/2)-20
1720 B=(NPTS/2)+20
1730 DO 174 I=A,B
1740 174 OUT1(I)=OUT1(I)*1.15
1750 WRITE(16,153) I,OUT1(I)+AMEAN1,OUT3(I)+AMEAN2
1760 152 WRITE(6,153) I,OUT1(I)+AMEAN1,OUT3(I)+AMEAN2
1770 153 FORMAT('15.10X,G17.5,10X,G17.5')
1780 STOP
1790 ENI

```

```

C PROGRAM PROJECT: COMPUTES POWER SPECTRUM IN DB
  DIMENSION XIN(128),XOUT(128)
  COMPLEX WORK(128)
  CHARACTER*20 INFILE,OUTFILE

```

```

C
  WRITE(6,1)
1  FORMAT(12,'NUMBER OF SAMPLES IN INPUT :12 ? ')
  READ(5,2) NPTS
2  FORMAT(12)
  WRITE(6,3)
3  FORMAT(12,'WHAT IS THE INFILE? ')
  READ(5,4) INFILE
4  FORMAT(12)
  OPEN(UNIT=15,NAME=INFILE,STATUS='OLD')
  WRITE(6,5)
5  FORMAT(12,'WHAT IS THE CUTFILE? ')
  READ(5,6) CUTFILE
  OPEN(UNIT=16,NAME=CUTFILE,STATUS='NEW')
  WRITE(6,6)
6  FORMAT(12,'WHAT IS THE SEL RATE:F5.2 ? ')
  READ(5,7) V
7  FORMAT(12)

```

```

C
  READ IN DATA
  LO 10 I=1,NPTS
12 READ(15,11) XIN(I)
11 FORMAT(25A,F6.5)
  CALL CLEAR(WCRK,128)
  CALL COMPLEX(XIN,WORK,128)
  CALL FFT(WCRK,NPTS,128)
  CALL POWERDB(WCRK,128)
  CALL REALPART(XCUT,WCRK,128)
  CINT=NPTS/V
  FC 100 I=2.65
  XI=I-1
  FREQ=XI/CINT
142 WRITE(16,122) FREQ,XCUT(1)
122 FORMAT(F10.5,10X,F10.5)
  STOP
  ENL

```

```

C      PROGRAM VARIMAX: SIMPLICITY NORM
      DIMENSION XIN(128)
      CHARACTER*20 INFILE
C      -----
1      WRITE(6,1)
2      FORMAT(2) HOW MANY SAMPLES IN THE INPUT ? :I2 ')'
3      WRITE(6,3)
4      FORMAT(4) WHAT IS THE INFILE ? ')'
5      READ(5,4) INFILE
6      OPEN(UNIT=15,NAME=INFILE,STATUS='OLD')
7      DO 9 I=1,N
8      READ(15,*) XIN(I)
9      V1=0.0
10     V2=0.0
11     V=0.0
12     DO 11 I=1,N
13     V1=V1+(XIN(I)**4)
14     V2=V2+(XIN(I)**2)
15     V=V1/(V2**2)
16     WRITE(6,100) V
100    FORMAT(' THE VARIMAX NORM IS ',G15.7)
      STOP
      END

```

```

PROGRAM WAVETEST
-----
PROGRAM GENERATES A MULTI-WAVELENGTH INPUT SIGNAL, AND
SIMULATES SEDIMENTATION RATE CHANGES WITH AN AUTO-MODULATION
BASED ON SIGNAL AMPLITUDE. THIS PROGRAM IS SIMILAR TO PROGRAM
ISOJUST, WHICH ACCEPTS OXYGEN ISOTOPE DATA AS THE CONTROLLING
INPUT.
-----
DIMENSION XXX(500,2), P(500), BUF(500), DATA(500)
DIMENSION XNEW(500), XN1(500), XN2(500,2), XISO(500)
DIMENSION XN3(500), XN4(500), WCRK(1500)
COMPLEX CWORK(500)
CHARACTER*20 OUTFILE
-----
WRITE(6,80)
80 FORMAT(' INPUT NUMBER OF SAMPLES IN THE DATA SEQUENCE:13 ')
READ(5,1000) NS
1000 FORMAT('13')
WRITE(6,40)
40 FORMAT(' WHAT IS THE OUTPUT FILE NAME ? ')
READ(5,41) OUTFILE
41 FORMAT(A)
OPEN(UNIT=16,NAME=OUTFILE,STATUS='NEW')
-----
GENERATE RAW DATA
CALL WAVEGEN(XISC,NS)
CALL RANGE(XISO,NS,IMAX,IMIN,IX)
CALL MEAN(XISC,NS,IMEAN)
WRITE(6,15) IMAX,IMIN,IX,IMEAN
15 FORMAT(' MAX,MIN,RANGE, AND MEAN VALUE OF ISOTOPE CURVE: ',
14(2X,F8.2))
C
DO 50 I=1,NS
  XN1(I,1)=XISC(I,1)*10.0
  XN1(I,2)=XISO(I)
  NPIS=((XN1(NS,1))/10)+1)
  WRITE(6,90) NPIS
90 FORMAT(' NPIS= ',I4)
C
DEPTE ADJUSTMENT
DO 79 J=1,6
  FACTR=((J-1)/10.0)
  CCOUNT=0.0
  XNEW(1)=0.0
  DO 73 I=2,NS
    TERM=(2*(FACTR)*(ABS(XN1(I,2))))/IX
    IF(XN1(I,2)) 62,71,71
62 XNEW(I)=COUNT+(10.0)*(1.-TERM)
    CCOUNT=XNEW(I)
    GO TO 73
71 XNEW(I)=COUNT+(10.0)*(1.+TERM)
    CCOUNT=XNEW(I)
73 CONTINUE
C
SQUEEZE OR STRETCH XNEW TO SAME LENGTH AS XXX. (=NPIS)
NP=((XNEW(NS))/10)+1)
WRITE(6,10) NP
10 FORMAT(' NUMBER OF POINTS = ',I4)
ANPTS=NPIS
ANP=NP
DO 11 I=1,NS

```

```

11 XN1(I)=(XNEW(I)*(ANPTS/ANP))
INTERPOLATION: CURIC SPLINE
XN1(I) AND XISC(I) ARE USED AS INPUT, WITH THE NEW IEPTH SCALE
SPECIFIED AS XN3, OF LENGTH NPIS.
RECALCULATE ISOTOPIES ARE CONTAINED IN XN4.
C
C
C
DEPTH=0.0
XN3(1)=DEPTH
DO 30 I=2,NPTS
DEPTH=DEPTH+10.0
30 XN3(I)=DEPTH
CALL INTERPOLATE(XISO,XN1,XN4,XN3,WORK,NS,NPTS,IBAL,NF,NL)
NOPNT=NL-NF+1
WRITE(6,60) NOPNT
60 FORMAT('NUMBER OF POINTS ARE = ',I3)
C
STORE DATA
DO 100 I=1,NOPNT
100 WRITE(16,101) XN4(I)
101 FORMAT(1X,G15.7)
C
ANALYSIS OF DATA
CALL CLEAR(CWORK,500)
TRANSFER DATA INTO WORK AREA
CALL COMPIEX(XN4,CWORK,NOPNT)
ZEROMEAN AND DETREND (IF NECESSARY) THE DATA
CALL ZEROMEAN(CWORK,NOPNT)
MINICW THE DATA
CALL FROLATE(CWORK,NOPNT,G)
COMPUTE THE FCURIER TRANSFORM
MOPNT=IBINAFY(NOPNT)
CALL FFT(CWORK,NOPNT,MOPNT)
CALL POWERDE(CWORK,MOPNT)
C
CUTPUT RESULTS
MP=(MOPNT/2)
CALL REALPART(DATA,CWORK,MOPNT)
DO 45 I=1,MP
45 XI=I
FREQ=XI/MOPNT
IF (DATA(I+1).GT.-40.) GO TO 45
DATA(I+1)=-40.
WRITE(16,46) FREQ,DATA(I+1)
46 FORMAT(1X,G15.7,10X,G15.7)
C
CONTINUE
STOP
END
SUBROUTINE RANGE(X,NS,XMAX,XMIN,IX)
C
PROGRAM DETERMINES MAX,MIN VALUES AND AMPLITUDE OF A VECTOR.
DIMENSION X(500)
XMIN=X(1)
XMAX=XMIN
DO 50 I=1,NS
IF (X(I).LT.XMIN) XMIN=X(I)
IF (X(I).GT.XMAX) XMAX=X(I)
50 CONTINUE
DX=XMAX-XMIN
RETURN
END
SUBROUTINE MEAN(X,NS,AVG)
C
SUBROUTINE DETERMINES MEAN VALUE OF A VECTOR
DIMENSION X(500)
SUM=0.0

```

```

50  DO 50 I=1,NS
    SUM=SUM+X(I)
    AVG=(SUM)/NS
    RETURN
    END

```

```

C      SUBROUTINE CNVLRV(A,B,C,N,M)
      CONVOLVES A(N) WITH B(M). RESULT IS STORED IN C(N+M-1).
      DIMENSION A(1),B(1),C(1)
      DO 5 I=1,N+M-1
5      C(I)=0.0
      DO 10 J=1,M
      DO 10 J=1,M
10     C(I+J-1)=C(I+J-1)+A(I)*B(J)
      RETURN
      END

```

```

C      SUBROUTINE DECO(H,NP,XIN,XOUT,CNST)
SUBROUTINE DECO: TIME-DC MAIN DECCORVOLUTION
DIMENSION H(64),H1(64)
DIMENSION XIN(128),XCUT(128)
COMPLEX WORK(128)
-----
C      FOURIER TRANSFORM OF IRF
CALL CLEAR(WORK,128)
CALL COMPLEX(F,WORK,64)
C      CALL FFT(WORK,64,64)
BRING UP MODULUS WITH GAIN LIMITER
CALL POLAR(WORK,64)
CALL REALPART(H1,WORK,64)
DO 85 I=1,64
H1(I)=H1(I)+CNST
85 WORK(I)=CMPLX(H1(I),AIMAG(WORK(I)))
CALL CARTESIAN(WORK,64)
DO 110 I=1,64
110 WORK(I)=(1.0,0.0)/WORK(I)
CALL FFTINVERSE(WORK,64)
CALL REALPART(H1,WORK,64)
C      NORMALIZE COEFFICIENTS TO UNITY
SUM=0.0
DO 125 I=1,64
125 SUM=SUM+H1(I)
DO 126 I=1,64
126 H1(I)=H1(I)/SUM
CALL CNVLV(XIN,H1,XOUT,NP,64)
RETURN
END

```



```

100 SUBROUTINE GSIRF(AA,DEP,DIF,V)
110 SUBROUTINE USIRS OFFICER AND LYNCH(1983) APPROXIMATION OF THE
120 GUINASSO-SCHINK EQUATION TO GENERATE AN IMPULSE RESPONSE FUNCTION
130 IIF IS 64 POINTS LONG
140 DIMENSION AA(64)
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SUBROUTINE WAVGEN(X,NS)
*****
INSERT: WAVGEN GENERATES A MULTI-WAVELENGTH SIGNAL
WAVE AMPLITUDES ARE SCALARS: AMP,BMP,CMP,DMP
WAVE FREQUENCIES ARE HELD AS (2*PI)/(WAVELENGTH): AF,BF,CF,DF
DIMENSION A(500),B(500),C(500),D(500),X(500)
PI=3.14159
AMP=1.0
BMP=1.0
CMP=1.0
DMP=0.0
AF=(2*PI)/21.0
BF=(2*PI)/8.22
CF=(2*PI)/4.62
DF=(2*PI)/2.3
WRITE(6,1000)
1000 FORMAT(' COMPONENTS OF THE INPUT TEST SIGNAL ')
DO 10 I=1,NS
  10 A(I)=AMP*(SIN(AF*I))
  WRITE(6,1001) AMF,AF
1001 FORMAT(' WAVE AMPLITUDE = ',F6.2,'; 2*PI/WVLGTH = ',F6.2)
DO 20 I=1,NS
  20 B(I)=BMP*(SIN(BF*I))
  WRITE(6,1001) BMF,BF
DO 30 I=1,NS
  30 C(I)=CMP*(SIN(CF*I))
  WRITE(6,1001) CMF,CF
DO 40 I=1,NS
  40 D(I)=DMP*(SIN(DF*I))
  WRITE(6,1001) DMP,DF
DO 100 I=1,NS
  100 X(I)=A(I)+B(I)+C(I)+D(I)
RETURN
END

```

```

C      ZEROMEAN ALGORITHM
      SUBROUTINE ZERC(A,N,AMEAN)
      DIMENSION A(1)
      AMEAN=0.0
      DO 10 I=1,N
10      AMEAN=AMEAN+A(I)/N
      DO 20 I=1,N
20      A(I)=A(I)-AMEAN
      RETURN
      END

```

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