U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

## NUCLEAR WASTE TECHNICAL REVIEW BOARD

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# Paleoclimate Records Implications for Future Climate Change

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U.S. DEPARTMENT OF THE INTERIOR · GEOLOGICAL SURVEY

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# INTRODUCTION

## I) Climate Forcing Functions at Millennial Time Scales

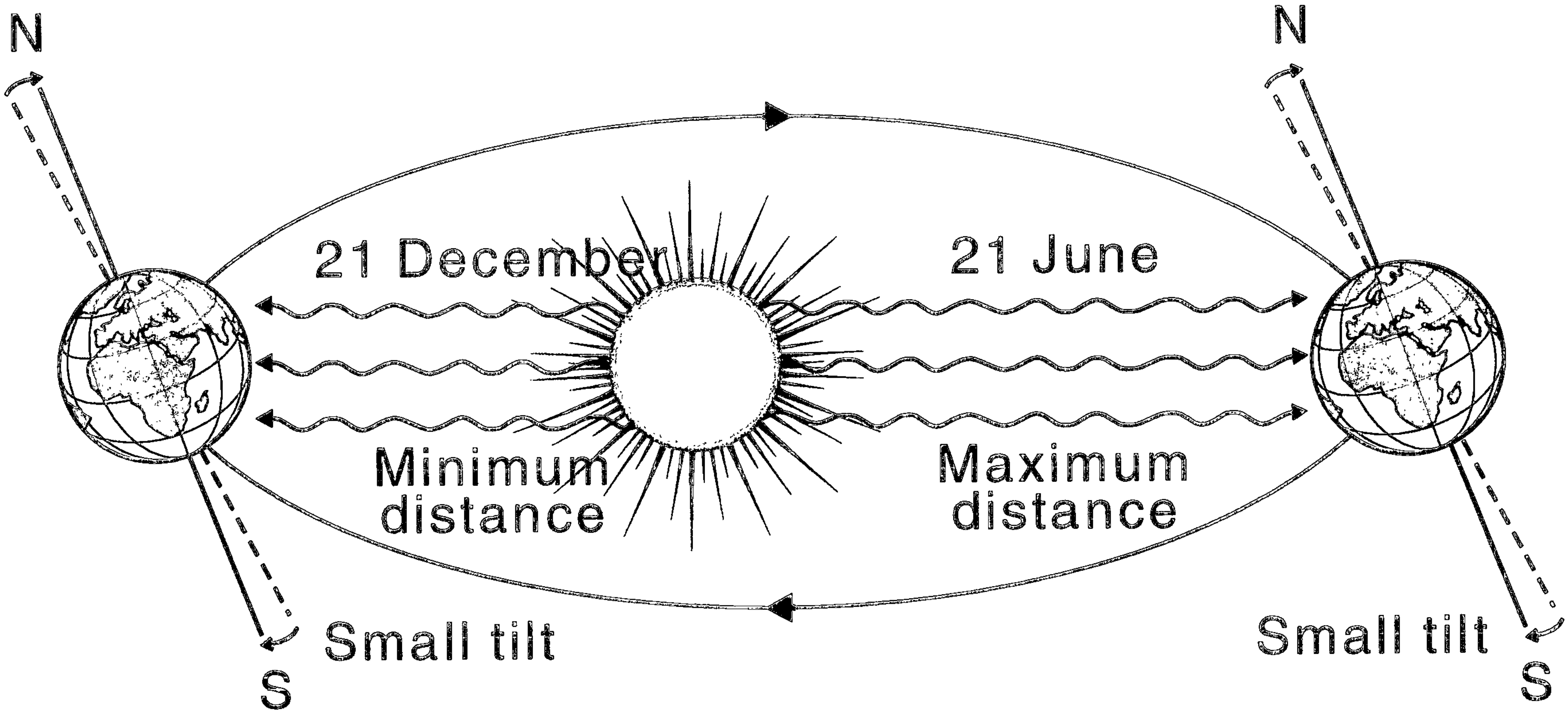
- Orbital Parameters and Insolation

## II) Climate Records of the Past 400,000 years (ky) from Southern Nevada

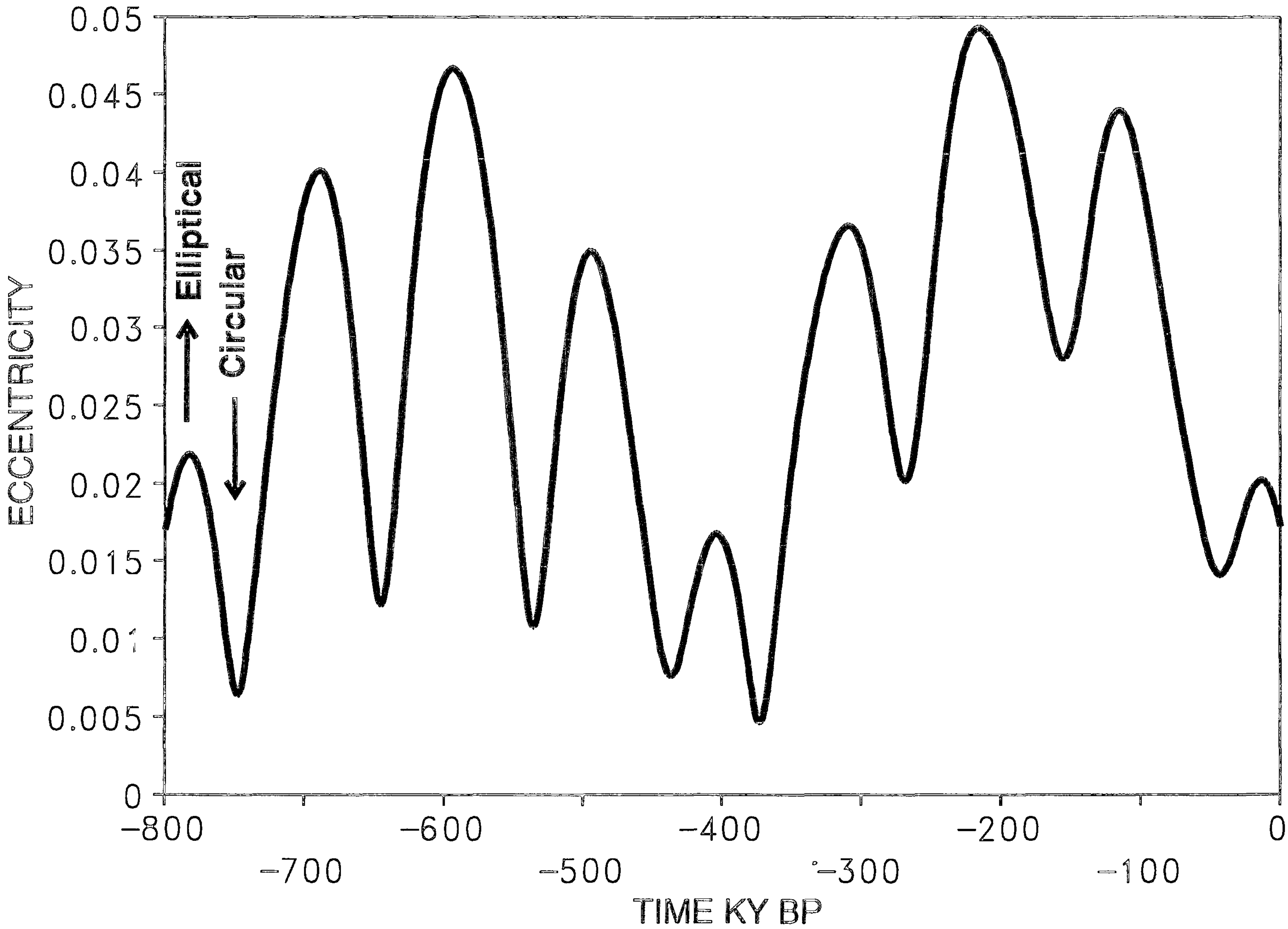
- Devils Hole Isotope Data
- Owens Lake Fossil and Isotope Data

## III) Multiproxy Climate Records from the Past Glacial Period <40 ky

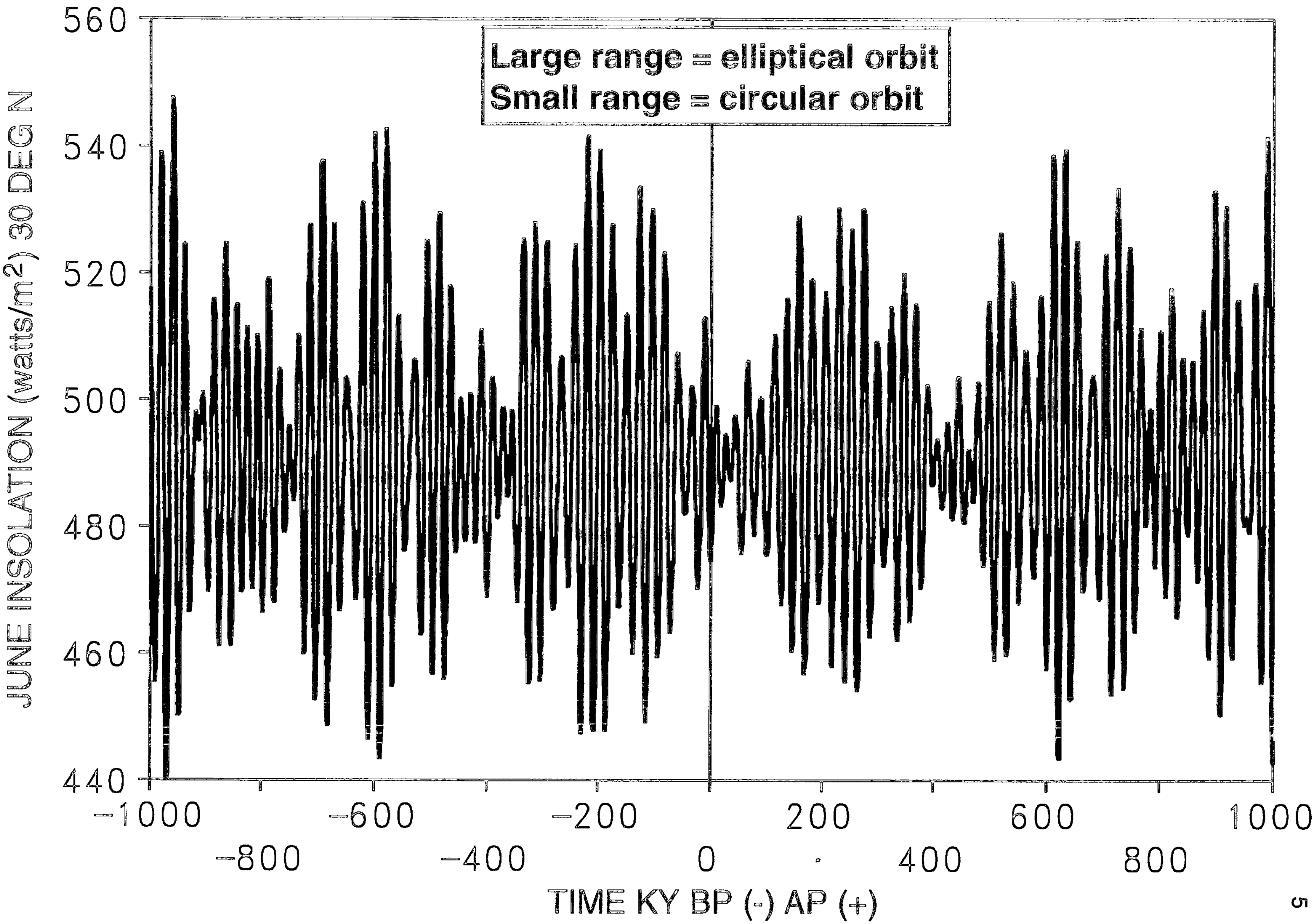
- Packrat Middens
- Ostracodes
- Diatoms
- Molluscs
- Isotopes


N
21 December
21 June
N
Minimum distance
Maximum distance
Small tilt
S
Small tilt
S

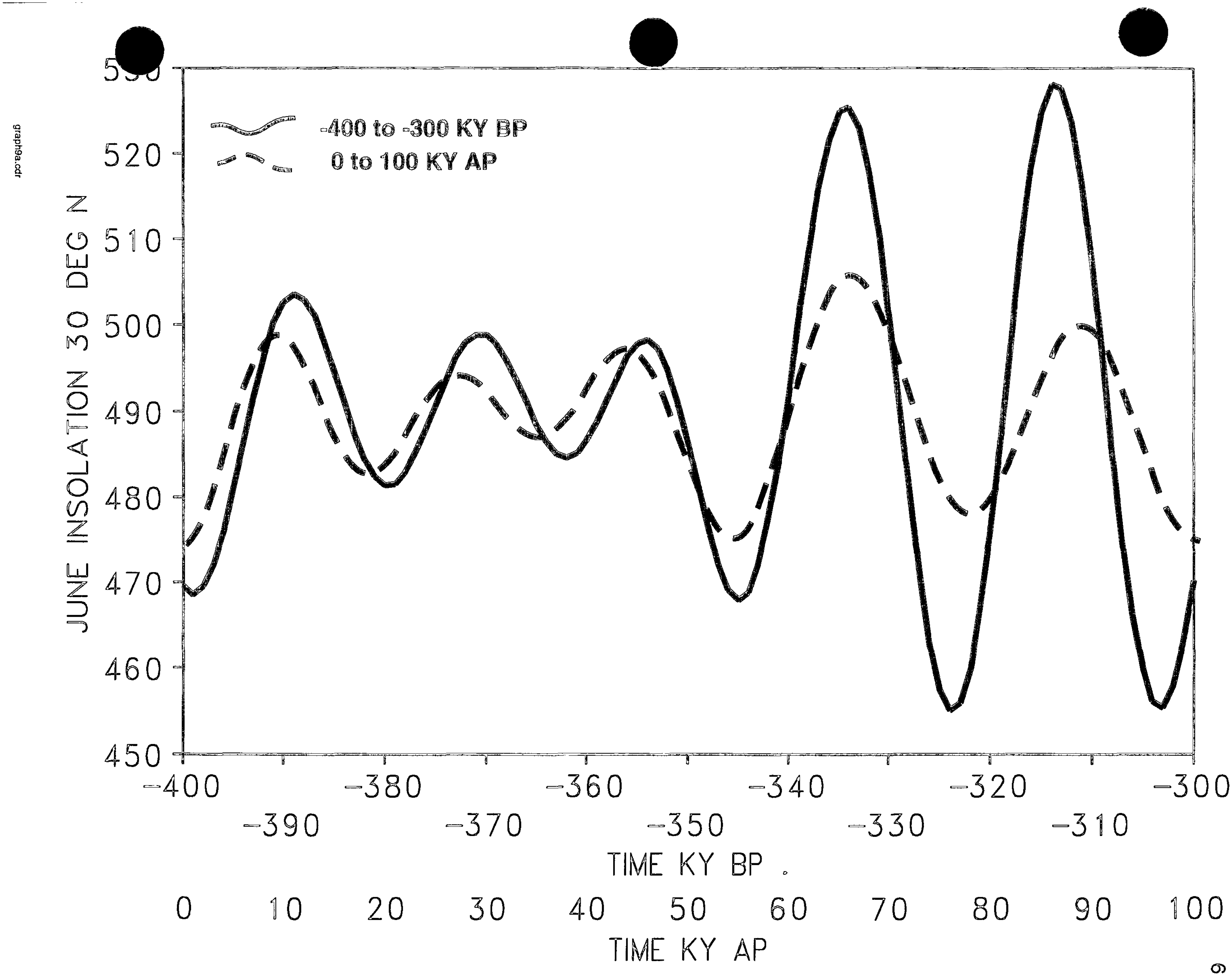
graph16.cdr



0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
ECCENTRICITY
Elliptical
Circular
-800
-700
-600
-500
-400
-300
-200
-100
0
TIME KY BP


Large range = elliptical orbit
Small range = circular orbit
JUNE INSOLATION (watts/m2) 30 DEG N
560
540
520
500
480
460
440
-1000
-800
-600
-400
-200
0
200
400
600
800
1000
TIME KY BP (-) AP (+)

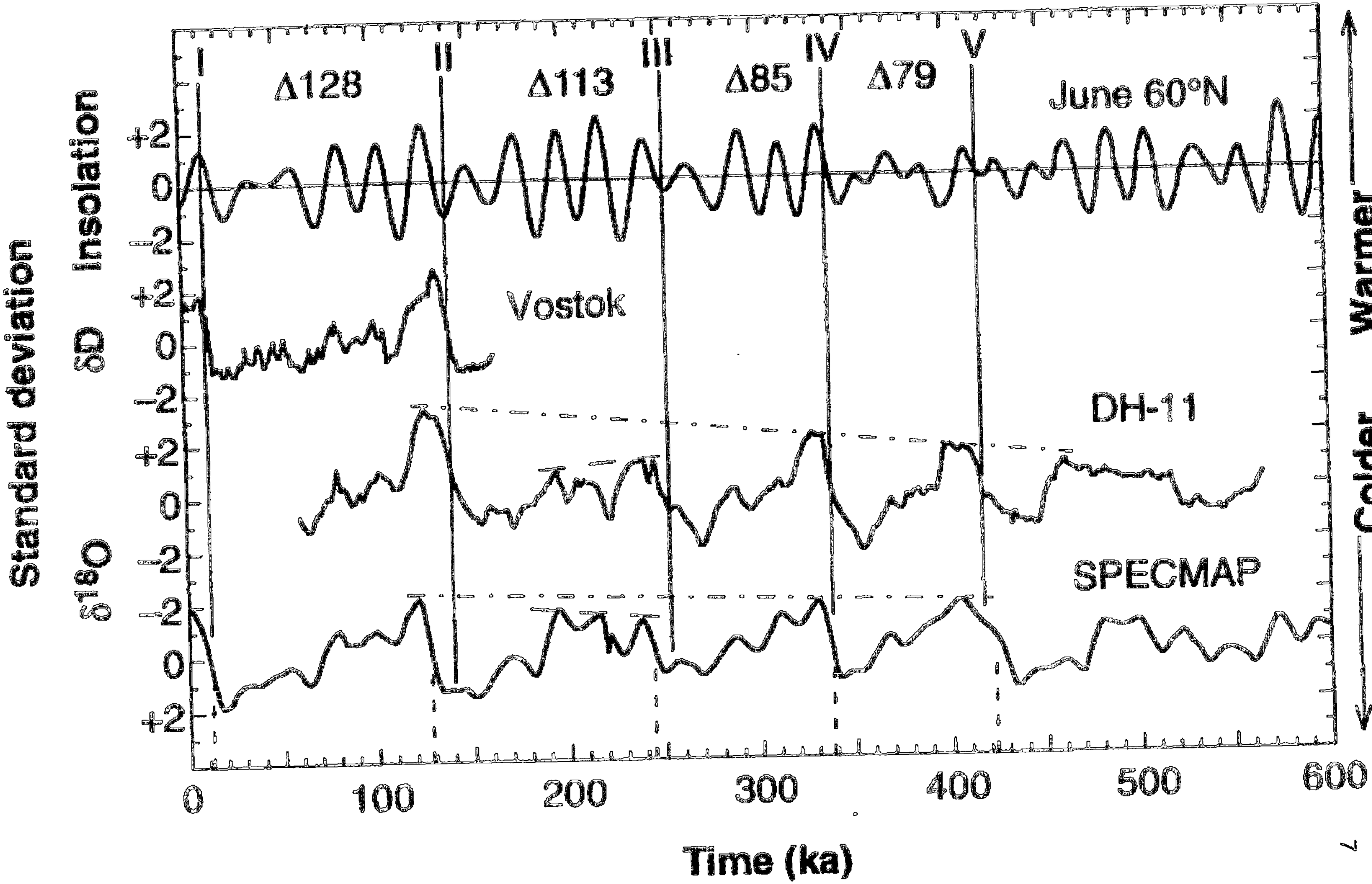
graph6.cdr

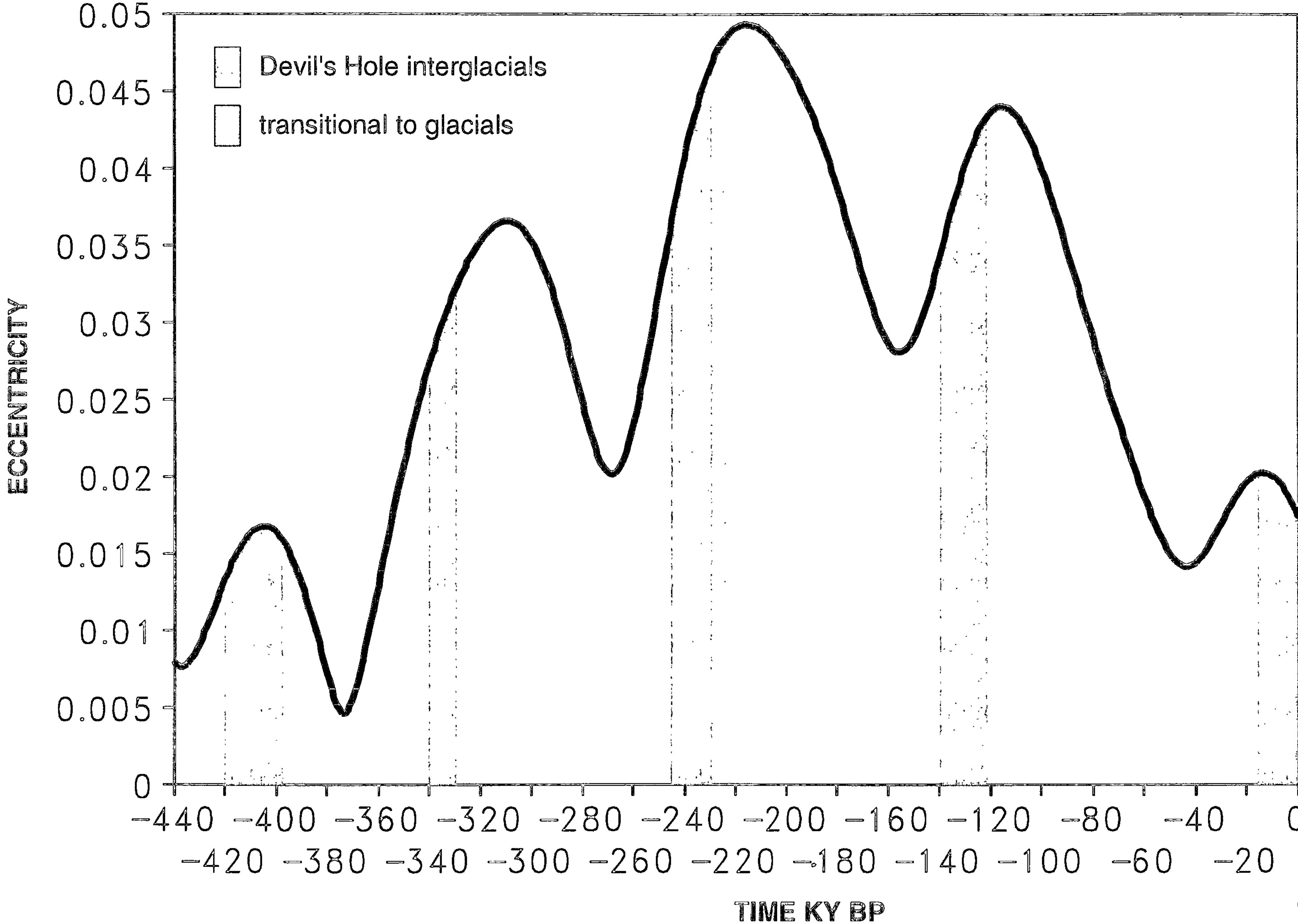


graph9a.cdr
-400 to -300 KY BP
0 to 100 KY AP
JUNE INSOLATION 30 DEG N
530
520
510
500
490
480
470
460
450
−400
−380
−360
−340
−320
−300
−390
−370
−350
−330
−310
TIME KY BP
0
10
20
30
40
50
60
70
80
90
100
TIME KY AP

winogra.cdr

from: Winograd, et al., 1992





Devil's Hole interglacials
transitional to glacials
ECCENTRICITY
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
−440 −400 −360 −320 −280 −240 −200 −160 −120 −80 −40 0
−420 −380 −340 −300 −260 −220 −180 −140 −100 −60 −20
TIME KY BP




graph1.cdr

# ESTIMATING FUTURE CLIMATE CHARACTERISTICS FROM PAST CLIMATE RECORDS

- Devils Hole record shows S. Nevada climate responds primarily to orbital (insolation) forcing functions on a millennial time scale.

- Orbital forcing functions may be calculated for the next climate cycle and offer a general guide for future climate change.

- The regional effect of future climatic changes may be evaluated by study of long-term past climate and hydrological records.

- Future 400 ky insolation-climate cycles should be similar to past cycles just as the 800 to 400 ky cycle was similar to the last cycle.

- Long term climatic forcing functions (tectonism, continental drift) will not change significantly in the next 400 ky.

# OWENS LAKE CLIMATE RECORD

## *RESPONSE OF OWENS LAKE HYDROLOGY TO CLIMATE CHANGE.*

- Primary source of water for the lake derived from snow and rain at high elevation in the surrounding mountains. Those waters are very dilute.

- Primary source of salts and an important secondary source of water derived from spring discharge at low elevation.

- During very wet cold climates the dilute river water completely dominates the lake resulting in a large, deep freshwater lake.

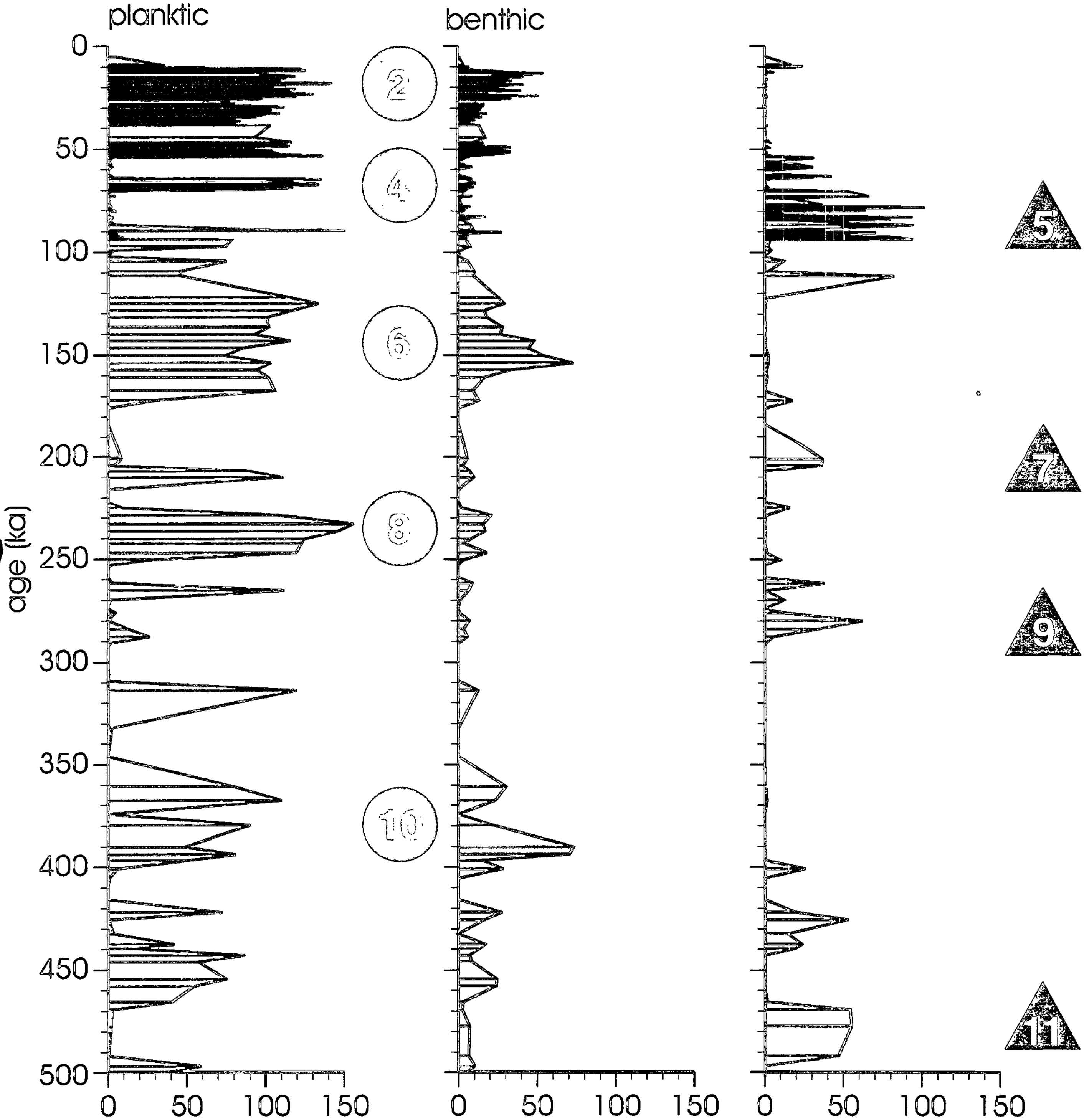
- During very dry climates spring discharge dominates the lake resulting in a shallow, warm or cool saline lake.

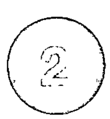
- Intermediate climates result in lakes with intermediate depths, thermal, and chemical characteristics.

- The volume, thermal, and chemical characteristics of past lakes may be interpreted from the fossil diatoms and ostracodes, transforming fossil data into climate data.

- Climate data derived from the fossils may then be compared with other records in the region like Devils Hole or with orbital parameters.

## Diatoms

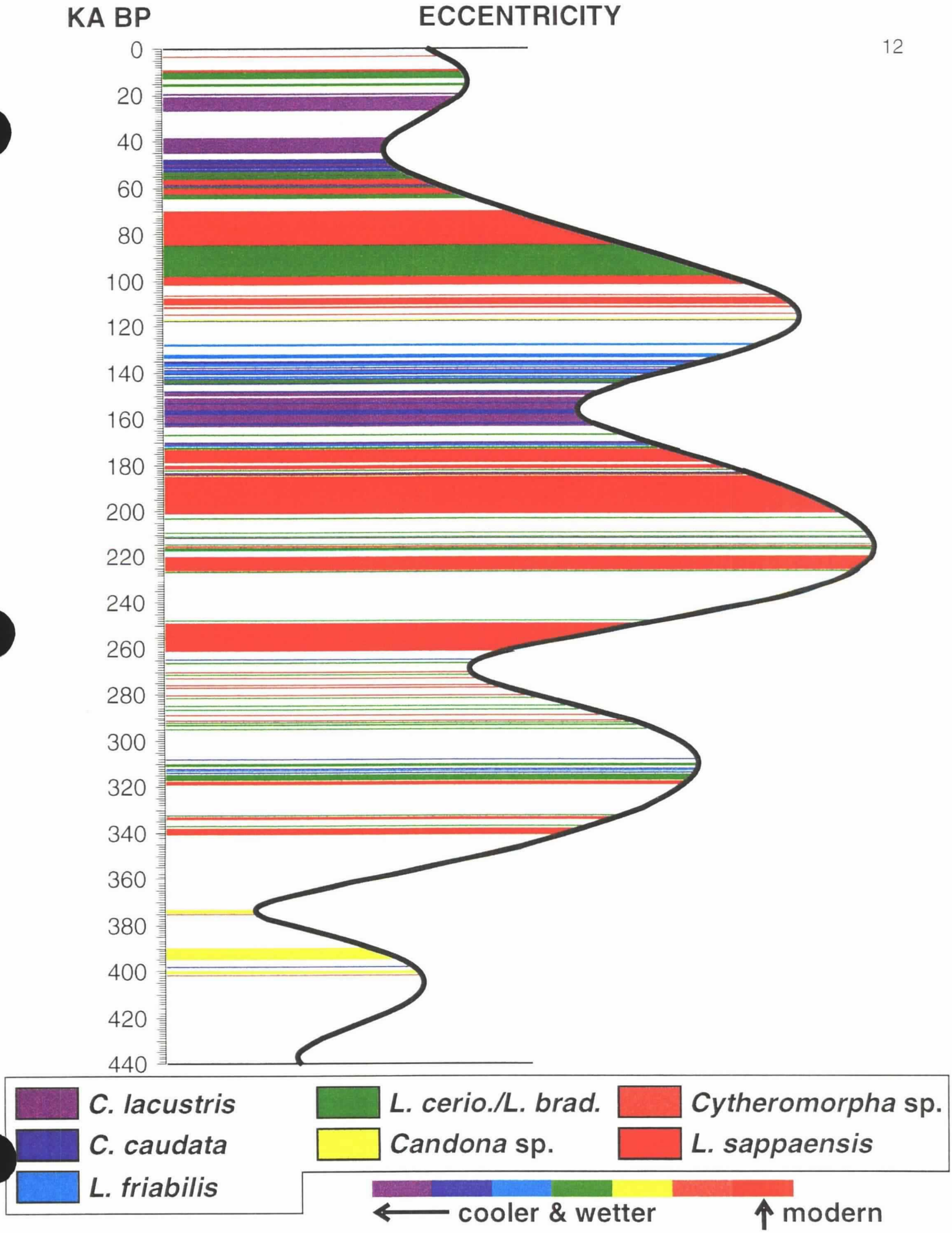


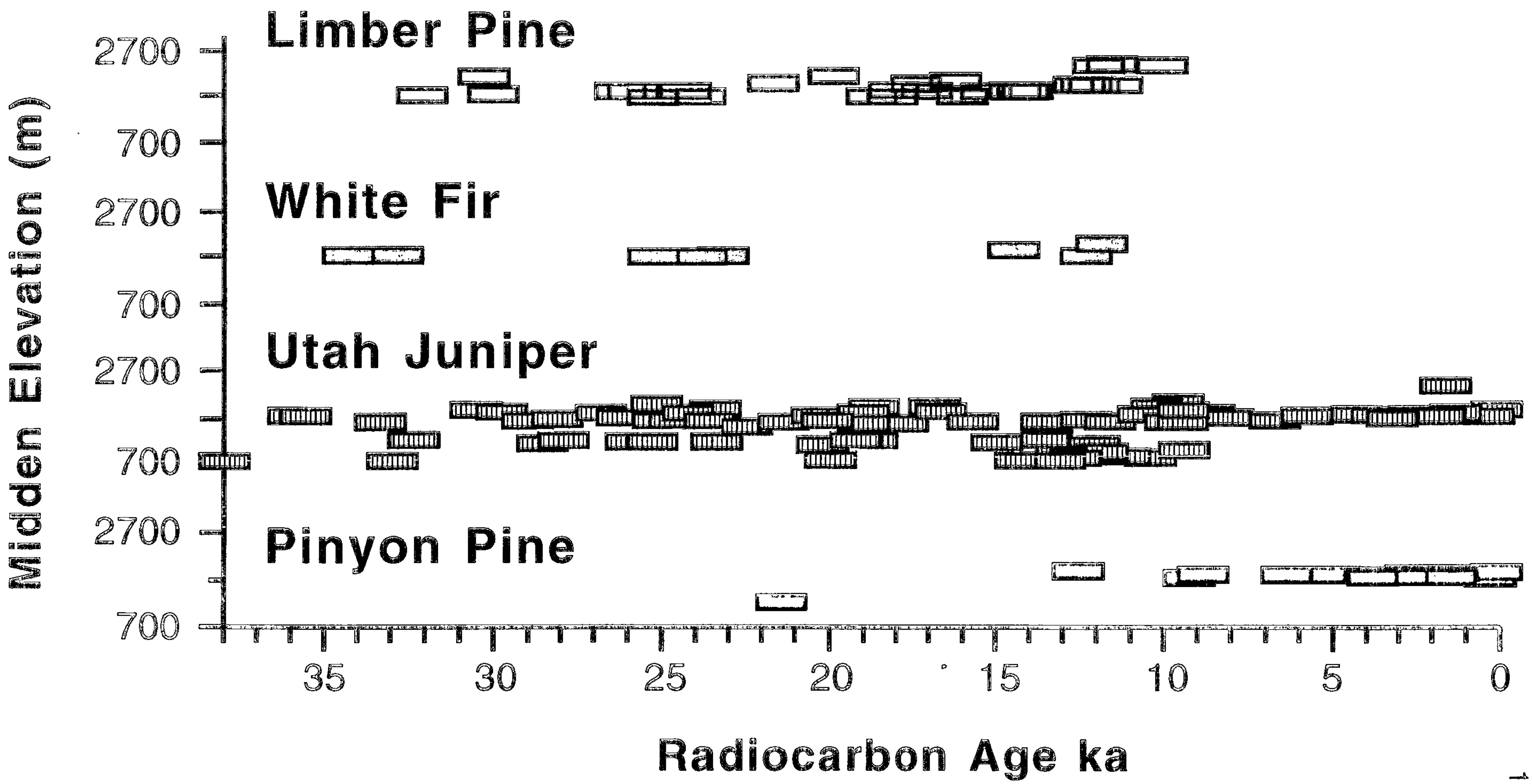
= **glacial periods (cold & wet)**

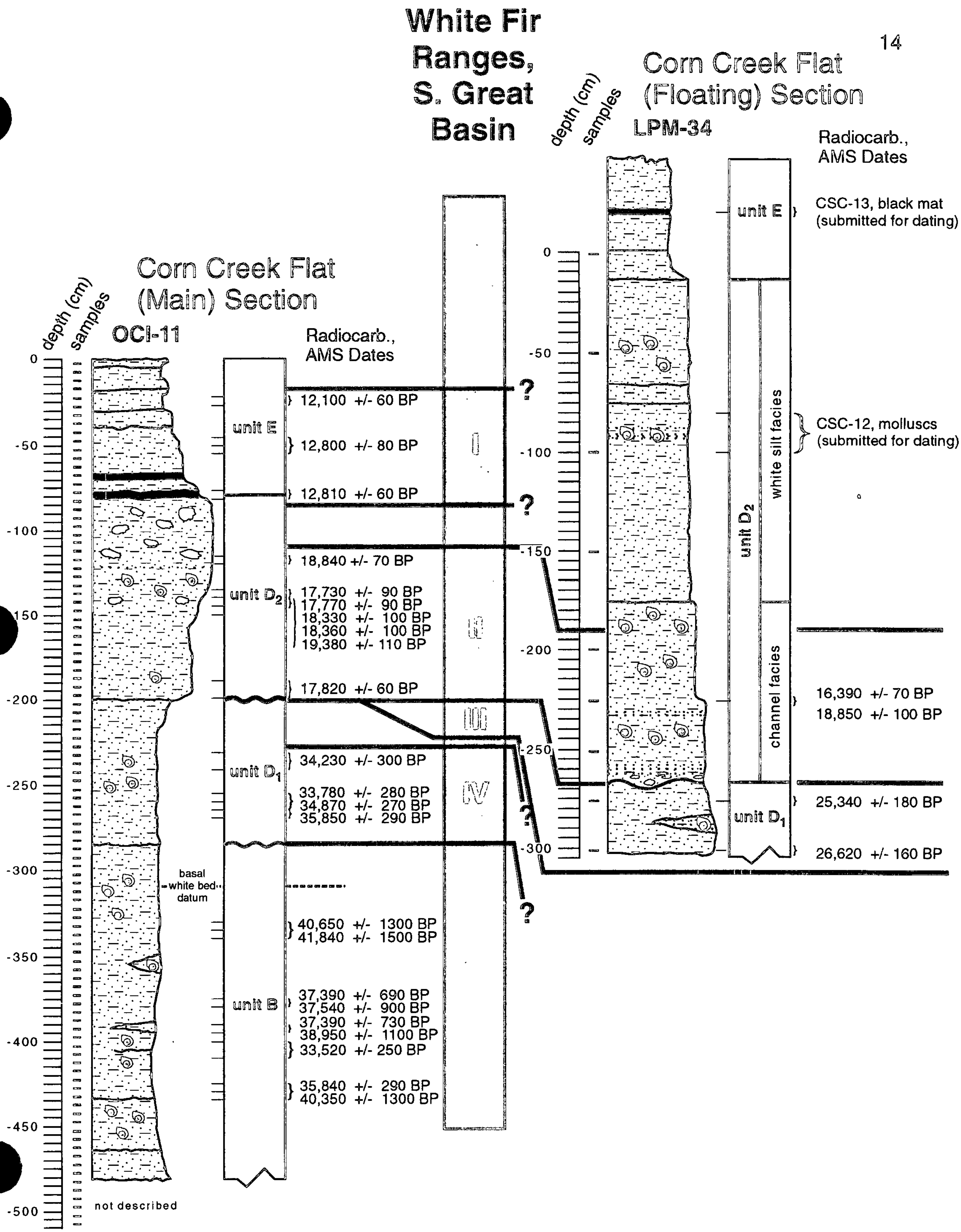
= **interglacial periods (warm & dry)**

graph15a.cdr


KA BP
ECCENTRICITY
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
C. lacustris
C. caudata
L. friabilis
L. cerio./L. brad.
Candona sp.
Cytheromorpha sp.
L. sappaensis
cooler & wetter
modern

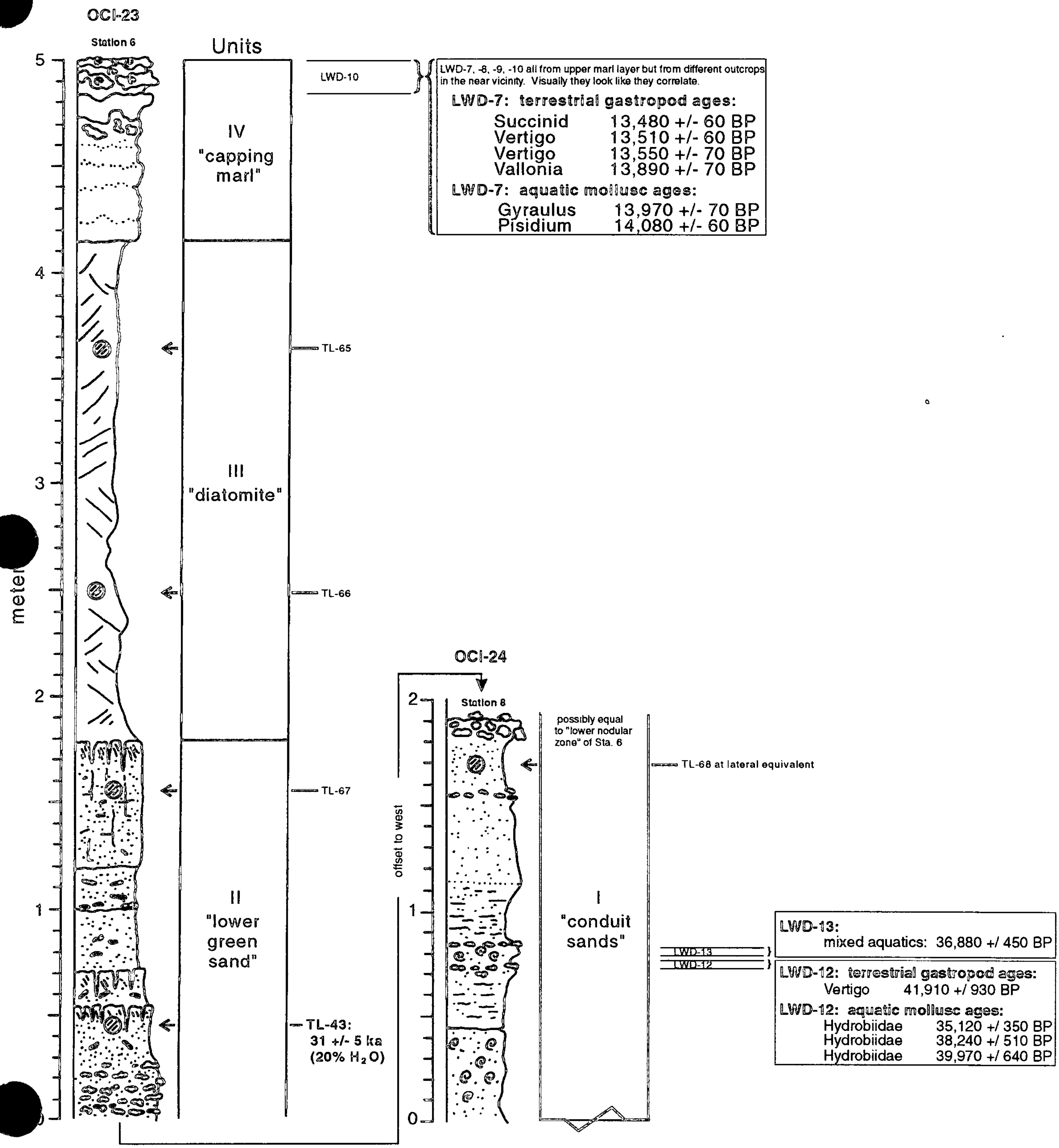
# Chronological Distribution Of Directly Dated Southern Great Basin Tree Species Showing Former Lower Elevational Limits Due To Colder & Wetter Climates



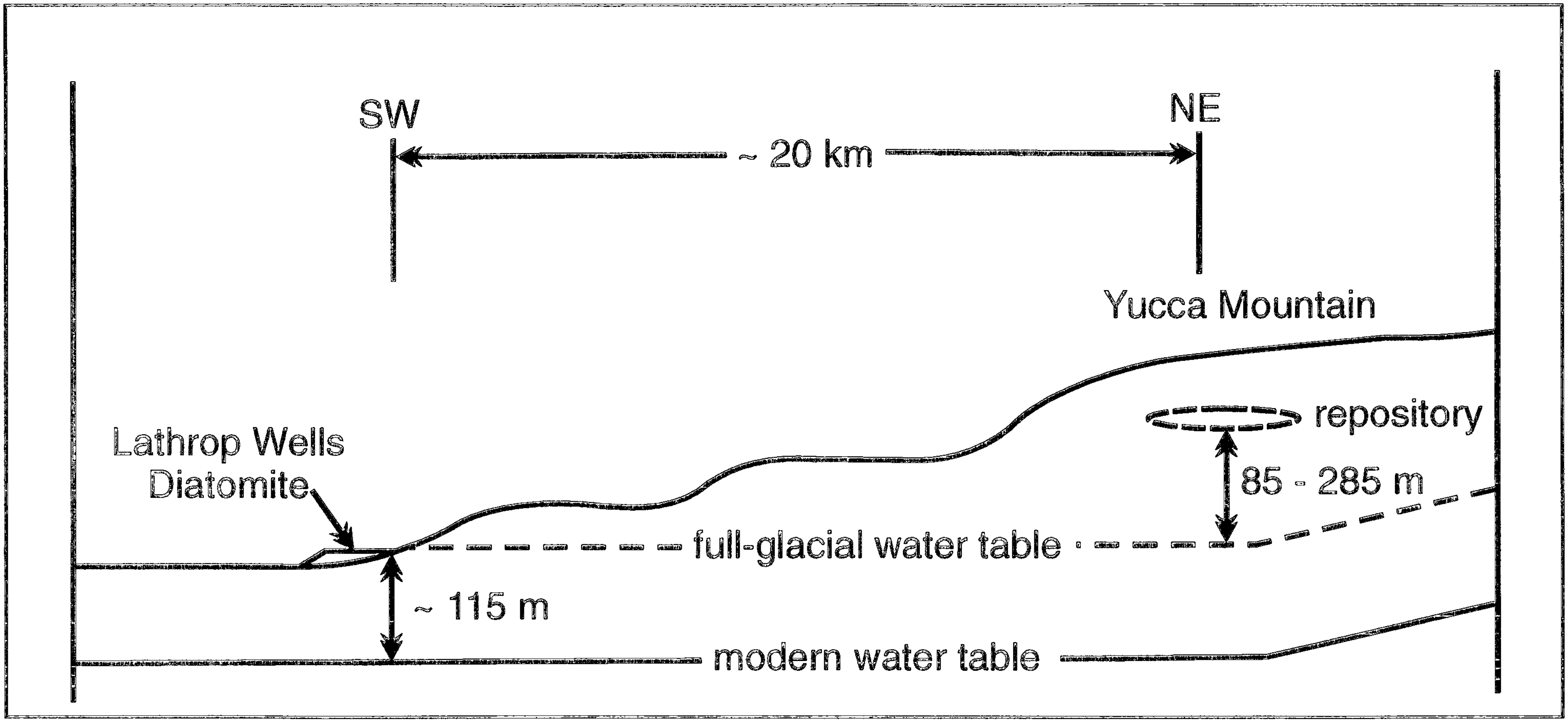

White Fir Ranges, S. Great Basin
Corn Creek Flat (Main) Section
OCI-11
depth (cm)
samples
Radiocarb., AMS Dates
unit E
unit D2
unit D1
unit B
12,100 +/- 60 BP
12,800 +/- 80 BP
12,810 +/- 60 BP
18,840 +/- 70 BP
17,730 +/- 90 BP
17,770 +/- 90 BP
18,330 +/- 100 BP
18,360 +/- 100 BP
19,380 +/- 110 BP
17,820 +/- 60 BP
34,230 +/- 300 BP
33,780 +/- 280 BP
34,870 +/- 270 BP
35,850 +/- 290 BP
basal white bed datum
40,650 +/- 1300 BP
41,840 +/- 1500 BP
37,390 +/- 690 BP
37,540 +/- 900 BP
37,390 +/- 730 BP
38,950 +/- 1100 BP
33,520 +/- 250 BP
35,840 +/- 290 BP
40,350 +/- 1300 BP
not described
I
II
III
IV
Corn Creek Flat (Floating) Section
LPM-34
unit E
unit D2
white silt facies
channel facies
unit D1
CSC-13, black mat (submitted for dating)
CSC-12, molluscs (submitted for dating)
16,390 +/- 70 BP
18,850 +/- 100 BP
25,340 +/- 180 BP
26,620 +/- 160 BP

cornc r2.cdr

# Lathrop Wells Diatomite (Horsetooth Site) Section



graph20.cdr




from: Marshall, Peterman and Stuckless, 1993; Quade, et al., 1995

# CONCLUSIONS

- Climate change cycles between dry and wet modes. In southern Nevada wet modes have existed about 70 percent of the time.
- A full climate cycle is about 400 ky long and contains roughly 100 ky subcycles each having glacial and interglacial conditions.
- Devils Hole shows the subcycles are < 100 ky early and are > 100 ky later in the 400 ky cycle.
- Climate cycles correlate with orbital parameters, which govern insolation; the key multi-millennial climate forcing function.
- Past climate-driven hydrologic change serves to estimate change in the future according to the known progression of future insolation cycles.
- Present-day dry climates may begin changing towards wet climates in about 1 ky based on past records or sooner if global warming persists according to some model interpretations.
- Current interpretation of Owens Lake data suggests the next wet period may not be as wet as the last (40 to 12 ka) or penultimate glacial (175 to 140 ka) periods.

# CONCLUSIONS, contd.

- During the last glacial period, higher effective moisture produced a 100 m rise in the regional water table near Yucca Mountain and supported wetlands and streams throughout the region. Drainage from the Amargosa River helped to support a large permanent lake in Death Valley.

- During the last glacial within 100 miles of YM, MAP likely varied from about 15 to more than 20 inches at some localities between 5 and 6 k feet with as yet unknown standard deviation and regional variability.