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Interpretation of seismic reflection data

I. Introduction

Seismic reflection data were examined as an aid to structural and stratigraphic studies within the basin. All available stratigraphic and velocity data were integrated to interpret the seismic data.

II. Procedures used in the identification of reflectors:

1. Compared of synthetic seismograms and VSP data from DOE wells with adjacent seismic reflection profiles.

2. Constructed time/depth plots using check shot data from petroleum exploration wells, in areas without synthetic seismograms.

3. Used regional isopach and structural data as aid to interpreting basement reflector.

III. Problems

1. Acquisition parameters were inappropriate for resolving deep structure.

2. "No-permit" areas resulted in degraded data.

3. Problems with statics corrections and velocity determinations produced misties with well data.

4. SWEC lines did not tie well to each other nor to lines from other surveys.

5. Poor velocity control reduced reliability of structure maps produced from seismic data.

6. Variablility in quality of data made it difficult to trace structures from line to line.

IV. Conclusions

1. The available seismic reflection data have been useful for examining the gross structural continuity of Permian strata within the Palo Duro Basin. However, details of faulting are still unresolved.

2. The accuracy of structure contour maps developed from the seismic data is probably low because of poor velocity control, both regionally and along individual lines.

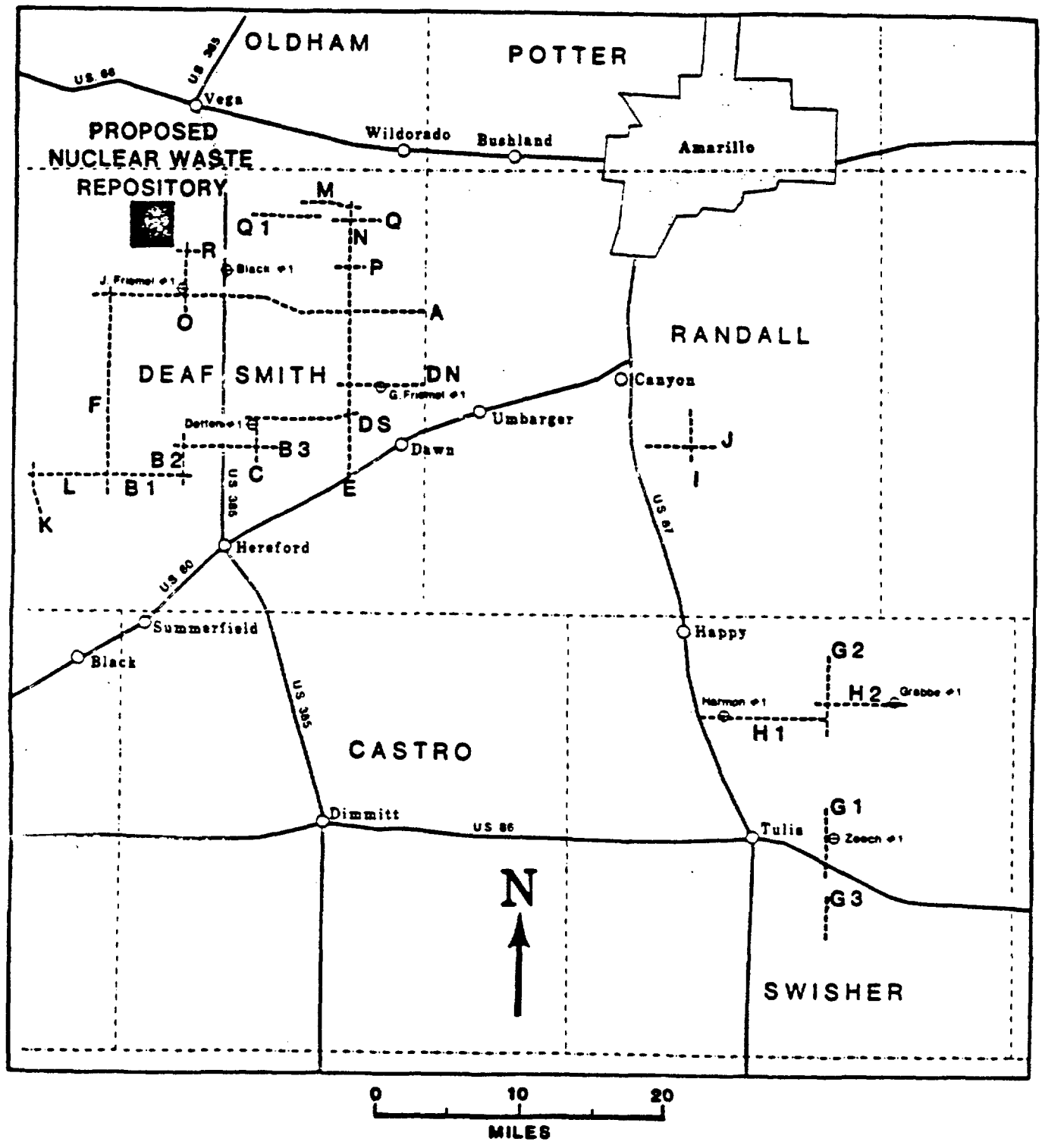

OLDHAM
POTTER
US 66
US 385
Vega
PROPOSED
NUCLEAR WASTE
REPOSITORY
Wildorado
Bushland
Amarillo
M
Q1
Q
N
R
Black #1
P
J. Friemel #1
O
A
RANDALL
DEAF SMITH
DN
G. Friemel #1
Canyon
F
Derrone #1
DS
Umbarger
B3
Dawn
J
B2
C
L
B1
E
I
K
US 385
US 87
Hereford
US 60
Summerfield
Happy
G2
H2
Grabbe #1
Harmon #1
H1
Black
US 385
CASTRO
Dimmitt
US 86
Tulia
G1
Zeech #1
G3
N
SWISHER
0
10
20
MILES

FIGURE 001

TABLE 1

LINE NUMBER	SHOT BY.	ENERGY SOURCE	FOLD % MSC	FREQUENCY* Hz	SPREAD feet	SOURCE SPACING FT
SWEC-A to B-3, D-I	Western	Vibroseis	24	12-90	2860-220-0-220-2860	110
SWEC-C #	Western	Vibroseis	24	18-128	2860-275-0-275-2860	110
SWEC-C +	Western	Vibroseis	48	18-128	2860-275-0-275-2860	55
SWEC-C @	Western	Vibroseis	48	18-128	5720-550-0-550-5720	110
SWEC-J	Western	Vibroseis	48	8-64	11220-880-0-880-11220	220
SWEC-K to R	Western	Vibroseis	24	12-90	2805-220-0-220-2805	110
BENDIX-D, F to H, J	Bendix-United	Vibroseis	12	12-40	4620-990-0-990-4620	330
BENDIX-E	Bendix-United	Vibroseis	12	12-40	4620-990-0-990-4620	330
75-2	Sundance	Dynamite	8	16-125	6600-220-0-220-6600	660
10-120	Sundance	Dynamite	12	16-125	5280-220-0-220-5280	440
PD-4, 4A, 9, 10, 11	STM	Vibroseis	24	15-75	8250-495-0-495-8250	330
W-95	Western	Vibroseis	24	8-64	7150-825-0-825-7150	275

Configuration A & B
+ Configuration C
@ Configuration D
in Figure 2

* notch @ 60

TABLE 2

List of DOE Test Wells

Well Name		County	Velocity Data*
GRUY-FEDERAL	#1 Rex White	Randall	ISL
SWEC	#1 Mansfield	Oldham	ISL
SWEC	#1 Sawyer	Donley	ISL
GRUY-FEDERAL	#1 Grabbe	Swisher	ISL, SS
SWEC	#1 Detten	Deaf Smith	ISL, SS
SWEC	#1 G. Friemel	Deaf Smith	ISL, SS
SWEC	#1 Harman	Swisher	ISL, SS, VS
SWEC	#1 Holtzclaw	Randall	ISL, SS, VS
SWEC	#1 J. Friemel	Deaf Smith	ISL, SS, VS, VSP
SWEC	#1 Zeeck	Swisher	ISL, SS, VS, VSP

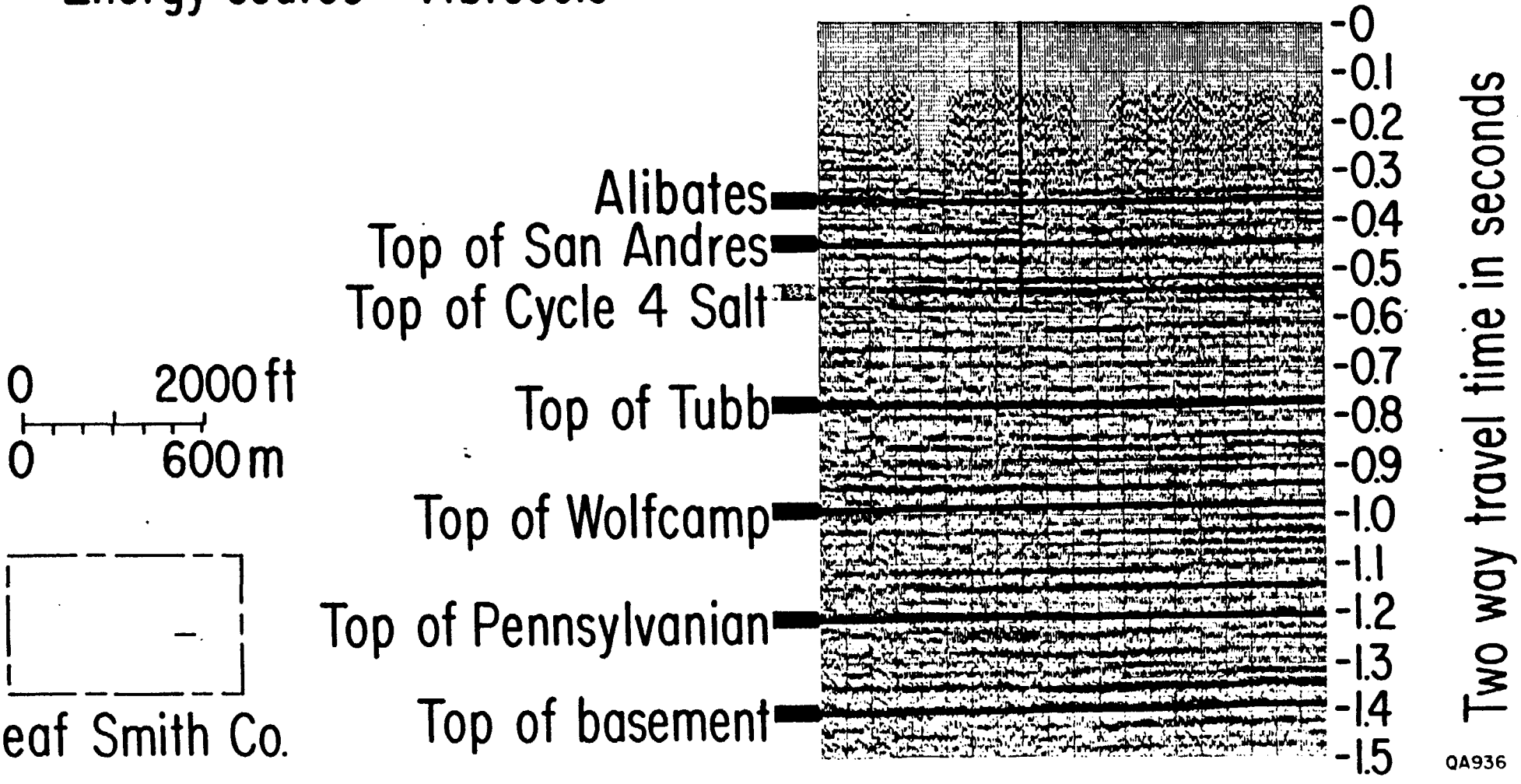
/elocity Data

ISL	Integrated sonic log
SS	Synthetic seismogram (geogram)
VS	Velocity survey
VSP	Vertical seismic profile

SEISMIC REFLECTION LINE
SWEC D-North

Fold : 2400 %

Energy source : Vibroseis



SEISMIC REFLECTION LINE
SWEC G-1

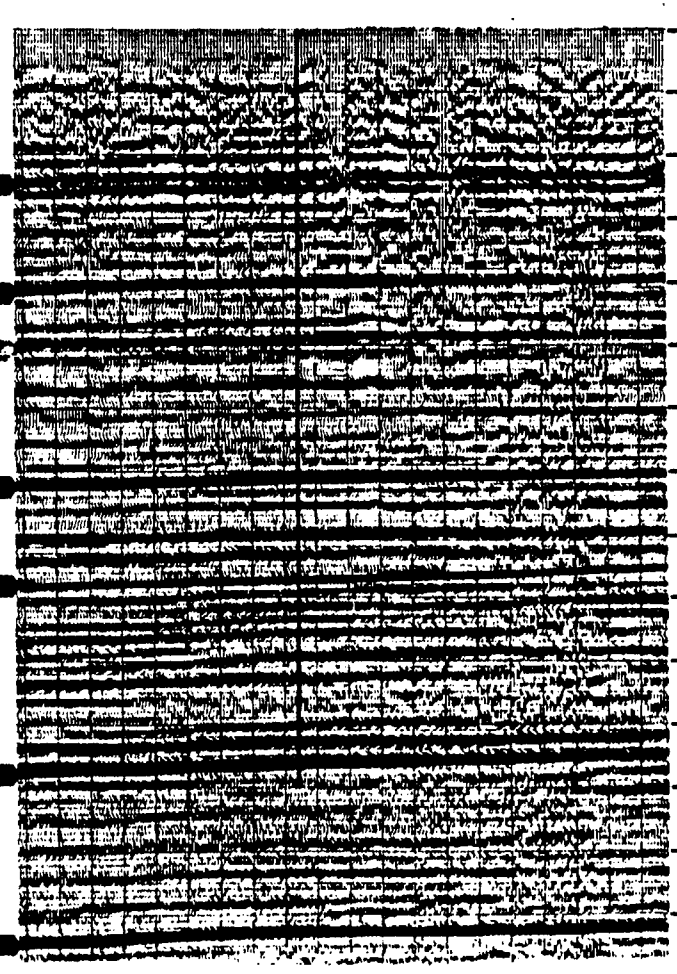
Fold : 2400%

Energy source : Vibroseis

Stone and Webster
#1 Zeeck

South WELL North

3500
3400
3300
Elev.

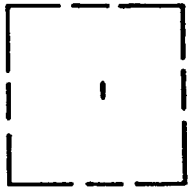


0 2000ft
0 600m

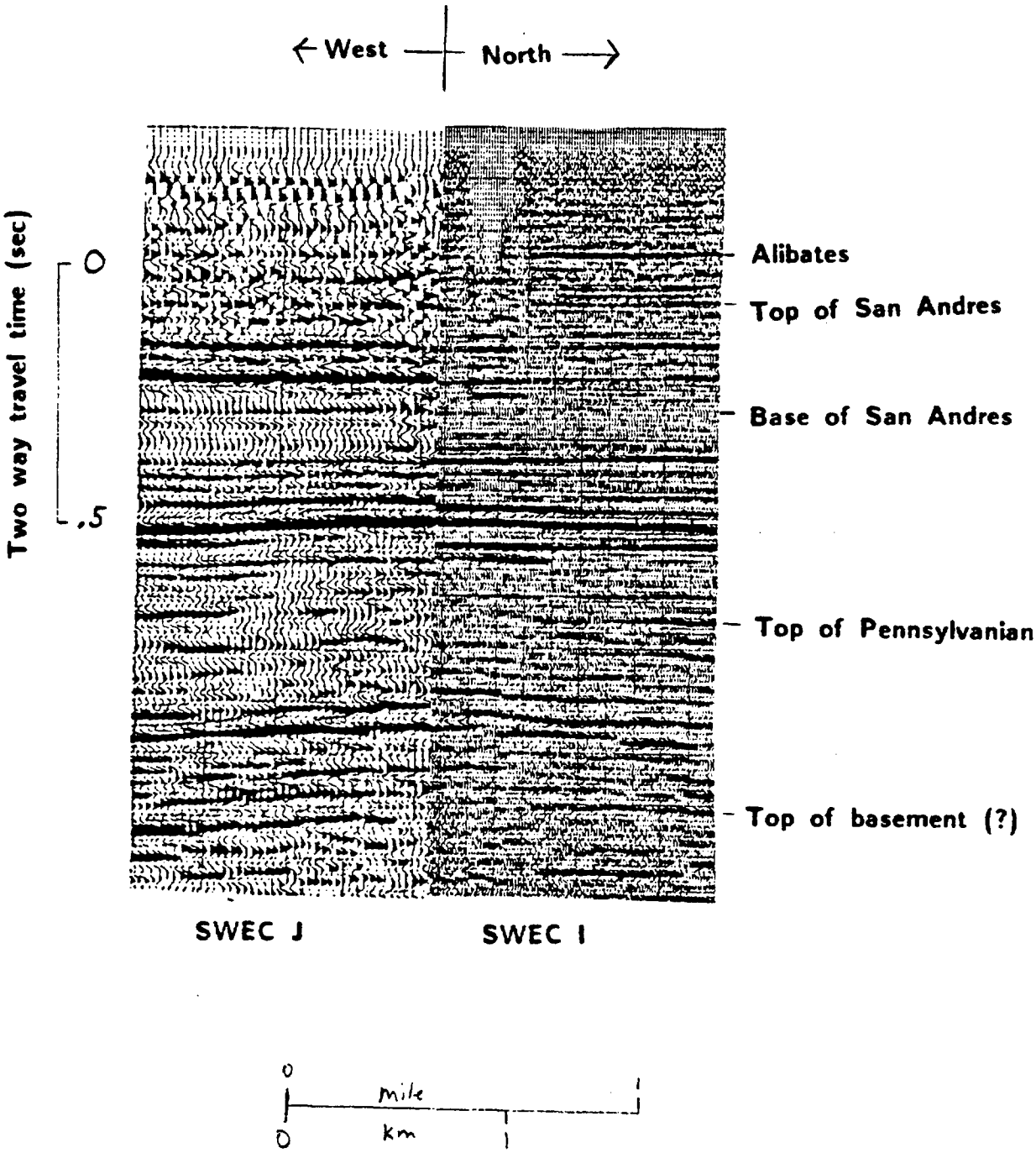
Alibates
Top of San Andres
Top of Cycle 4 Salt
Top of Tubb
Top of Wolfcamp
Top of Pennsylvanian
Top of basement

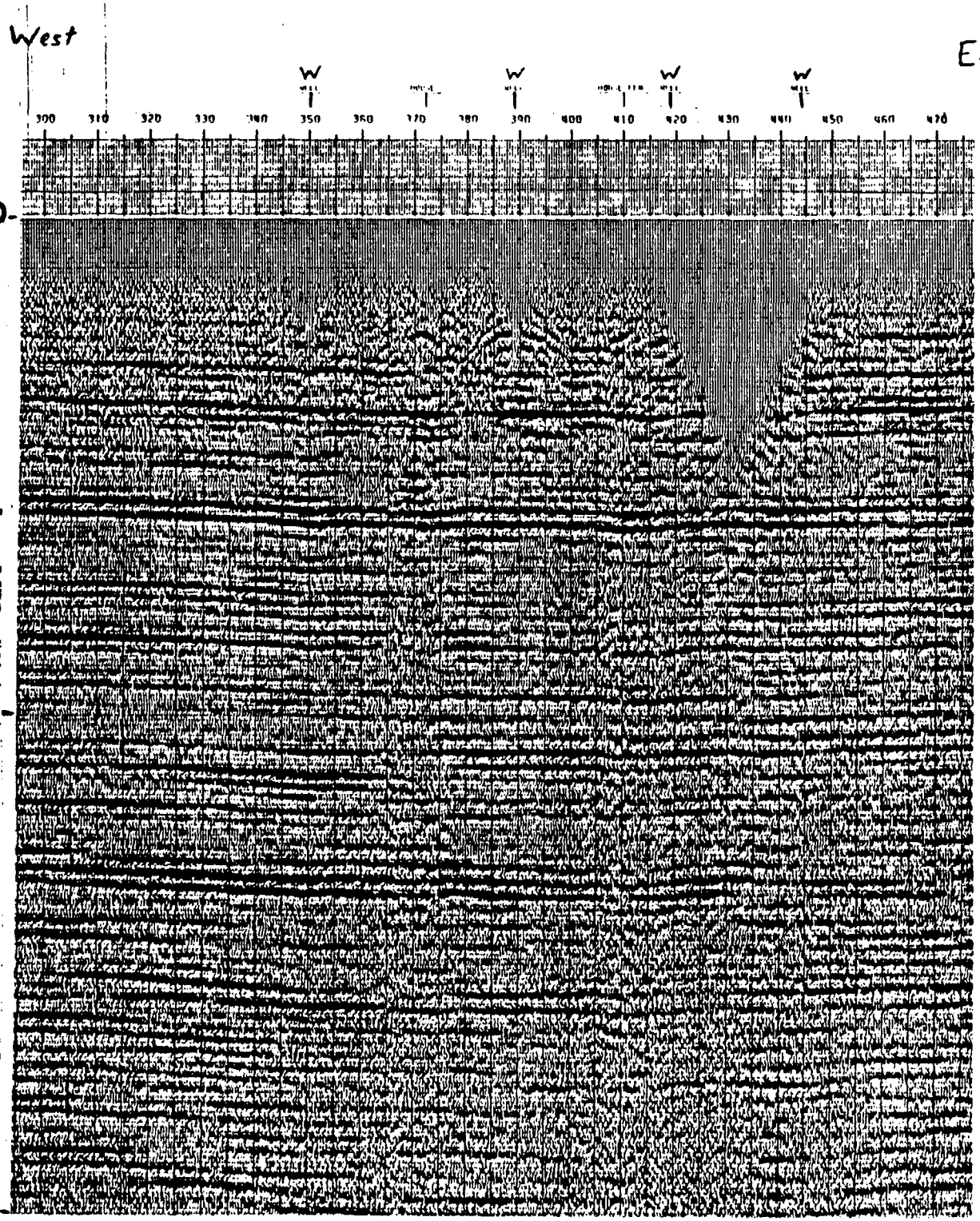
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4

Two way travel time in seconds



Swisher Co.


← West
North →
Two way travel time (sec)
0
.5
Alibates
Top of San Andres
Base of San Andres
Top of Pennsylvanian
Top of basement (?)
SWEC J
SWEC I
0
mile
1
0
km
1

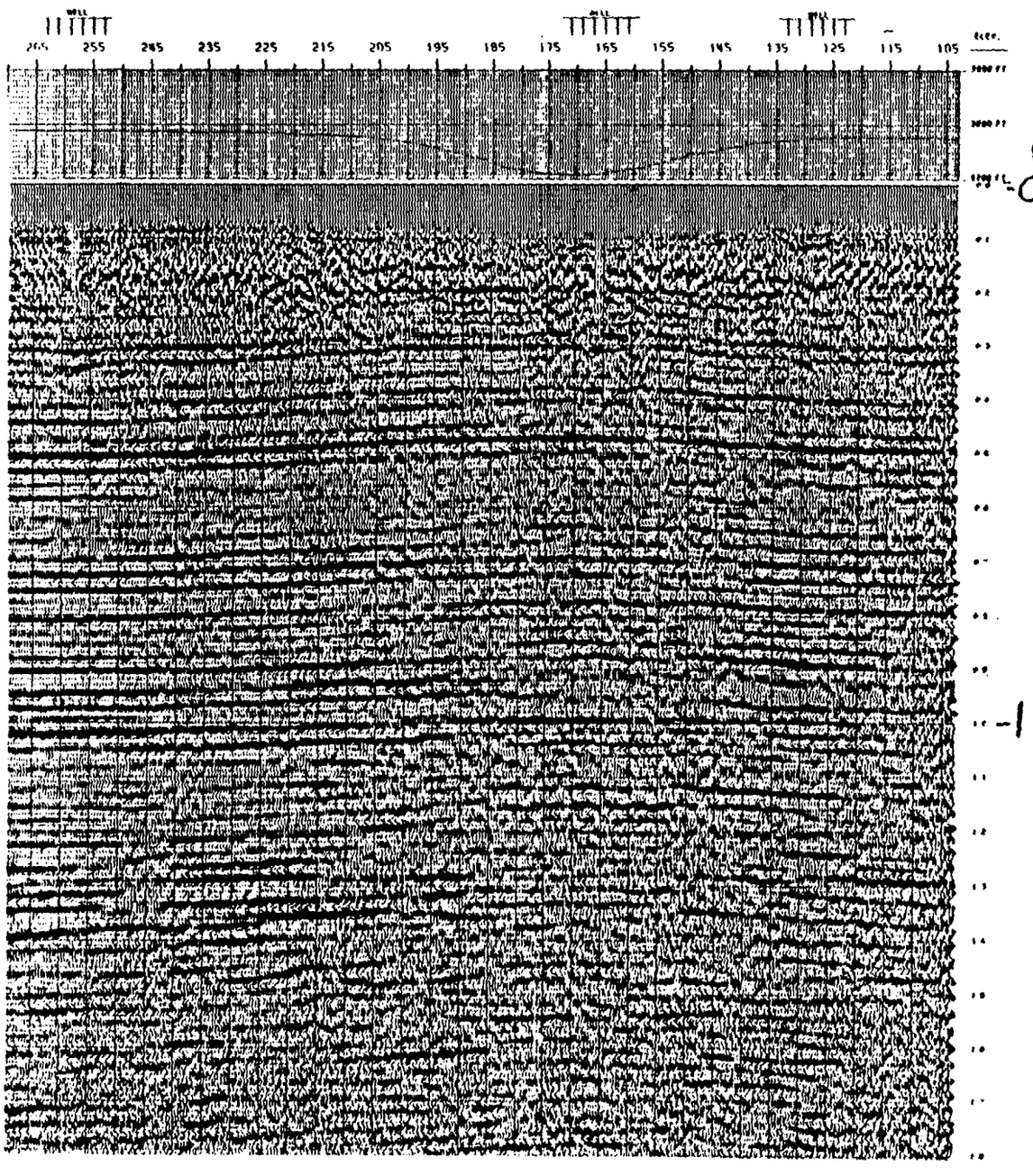


SWEC B-3

Distortion of data in vicinity of irrigation wells

mile

km



SWEC-Q

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Long (18)

PALO DURO BASIN PROJECT
INTERPRETATION OF SEISMIC DATA

1. VELOCITY DATA - Assemble, classify and integrate vertical velocity data with subsurface data. Reduce velocity data to a common reference datum. Determine reflection times for subsurface geologic markers at points of control.
2. MAPPING HORIZONS - Identify and select the reflections/subsurface horizons to be mapped. (USA, LSA1, Wc and PreC)
3. SUBSURFACE REFLECTION TRAVERSES - Identify and mark the reflection horizons to be mapped on the seismic sections. Close all seismic subsurface traverses by adjusting to compensate for loop misclosures. Revise seismic time horizons as required to tie at points where velocity and electric log data are available. Time the seismic horizons at appropriate intervals and post the times to a base map.
4. STRUCTURAL CONFIGURATION - Contour time maps.
5. SECONDARY ADJUSTMENTS - Utilizing the horizon dip attitudes indicated by the time structure maps, project and tie the horizons to offline points of velocity/subsurface control making adjustments to the seismic horizons and contour maps as required.
6. APPARENT AVERAGE VELOCITY MAPS - Determine the apparent average velocity to each mapped horizon at each well within the survey from the contoured time value of the horizon at the well and the depth of the corresponding subsurface marker. Post these values to a base map and contour the apparent average velocity configuration for each mapped horizon. The differences in apparent average velocity observed over the area represent a combination of lateral changes in the vertical velocity gradient and unresolved near surface corrections.
7. TIME-DEPTH CONVERSION - For each mapped horizon compare the time map postings with the apparent average vertical velocity configuration, determine the average velocity at that station, and convert reflection times to depths. Post these values to the base map. Prepare isopach maps and depth maps for each horizon.

Bruno (19)

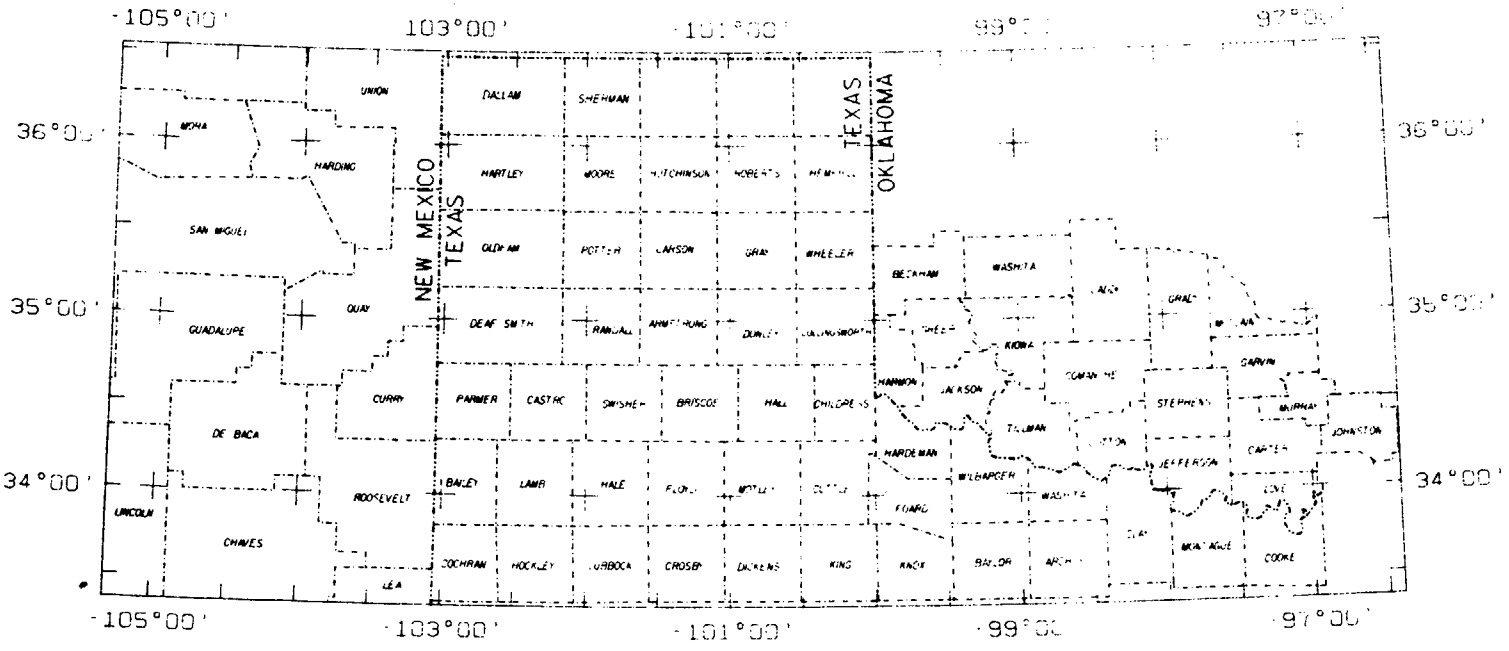
NRC WORKSHOP
November 19 - 21, 1985
Mapping from Geologic Data Base

I. Figures from previous reports

* Study Area
* X - Sections
* Block Diagrams
* Fence Diagrams

II. How these figures are made

* Data base
  - Geologic Interpretation
  - Procedures for Verification
* Preliminary Maps
  - Surface II Postings of data values
  - Surface II contours (thickness and elevation)
  - X-sections
* Hand drawn maps and sections
* finalized maps
  - Checking procedures



0 50 100 150 200

Scale: Miles

0 50 100 150 200

Scale: Kilometers

Explanation:

County boundary

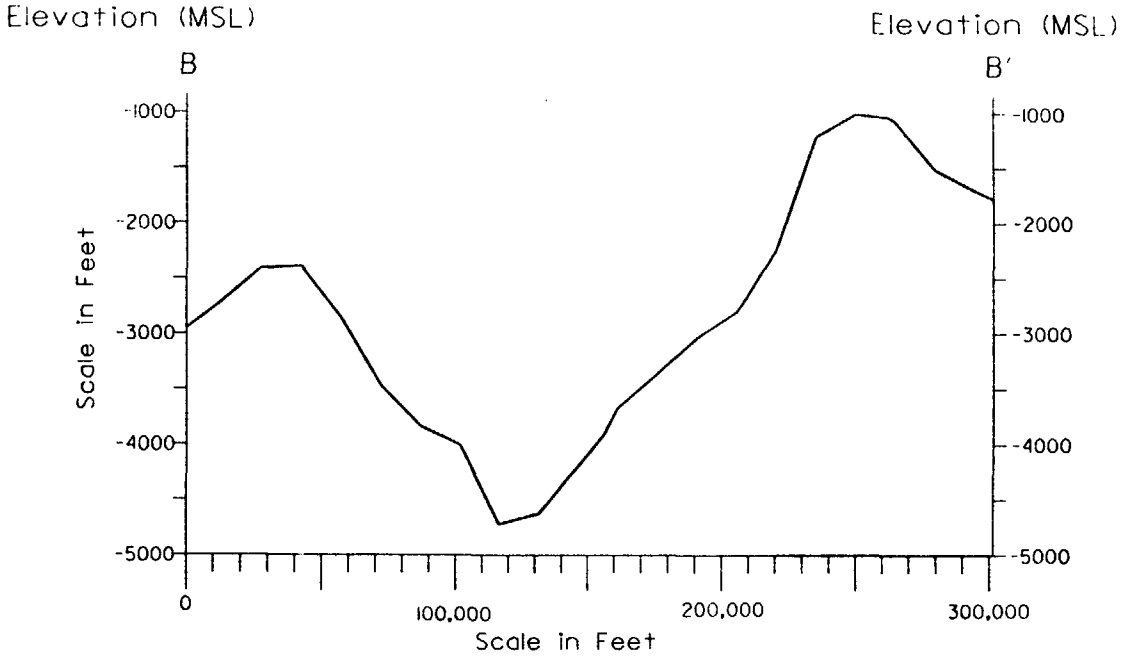
State boundary

Projection: Lambert Conformal

PRELIMINARY

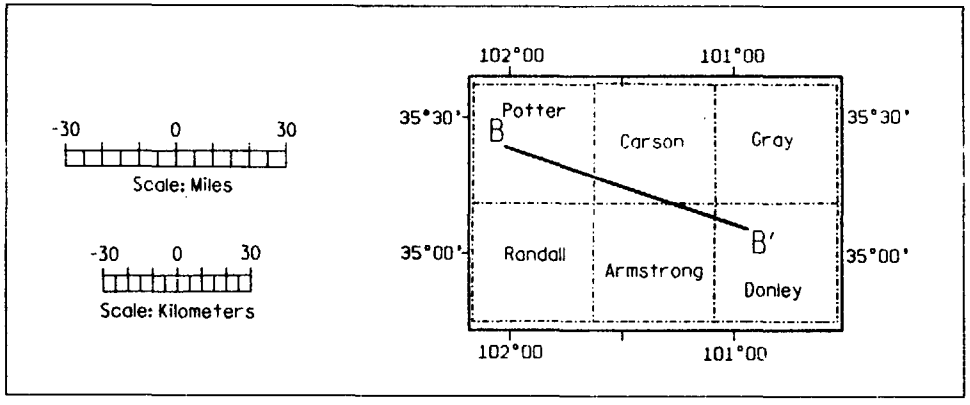
FOR COMMENTS ONLY

Extent of the Project Study Area



Note:

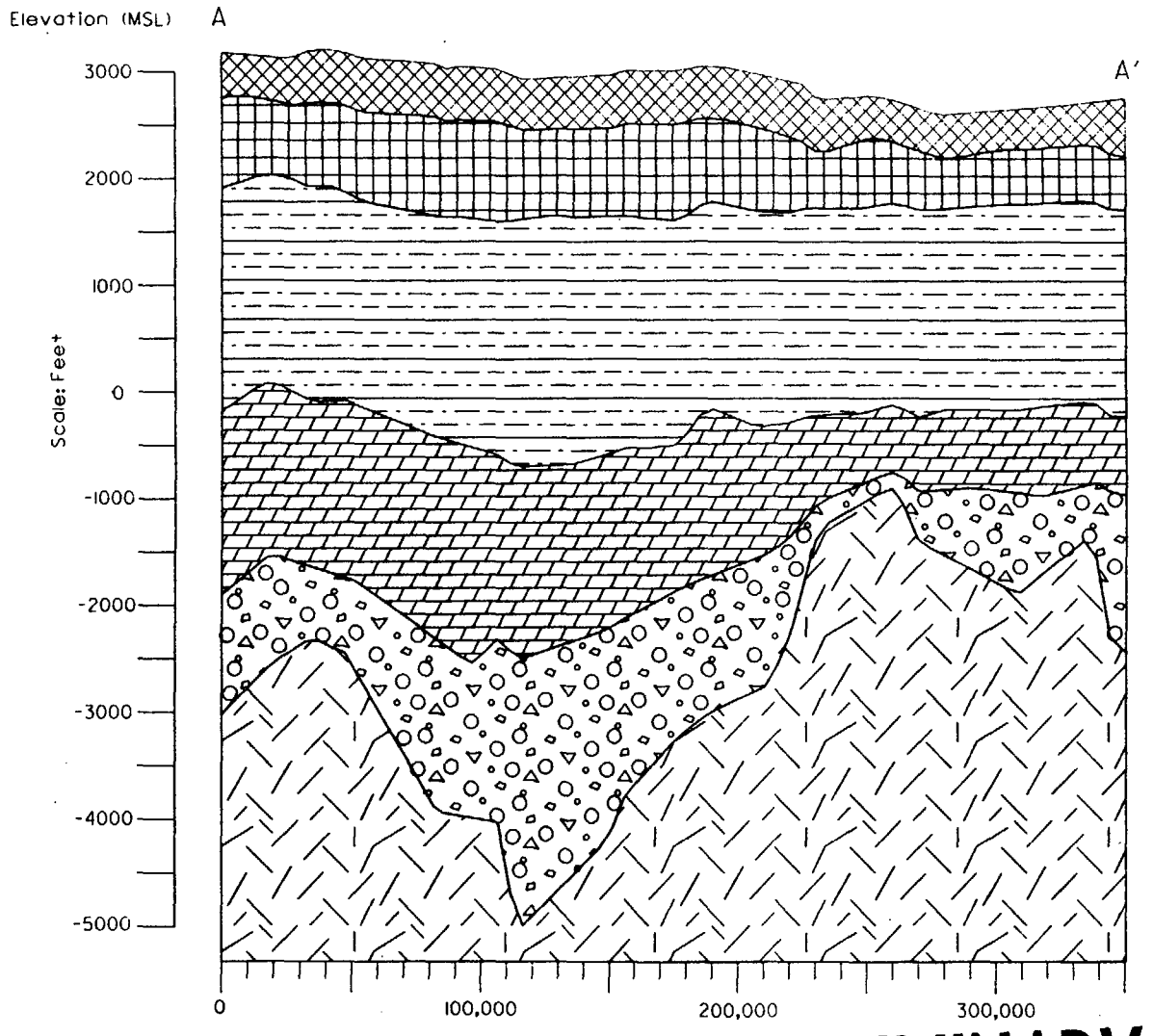
Vertical Exaggeration: 500x



PRELIMINARY

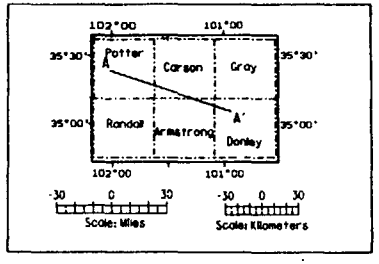
FOR COMMENTS ONLY

Cross Section of
a Single Horizon



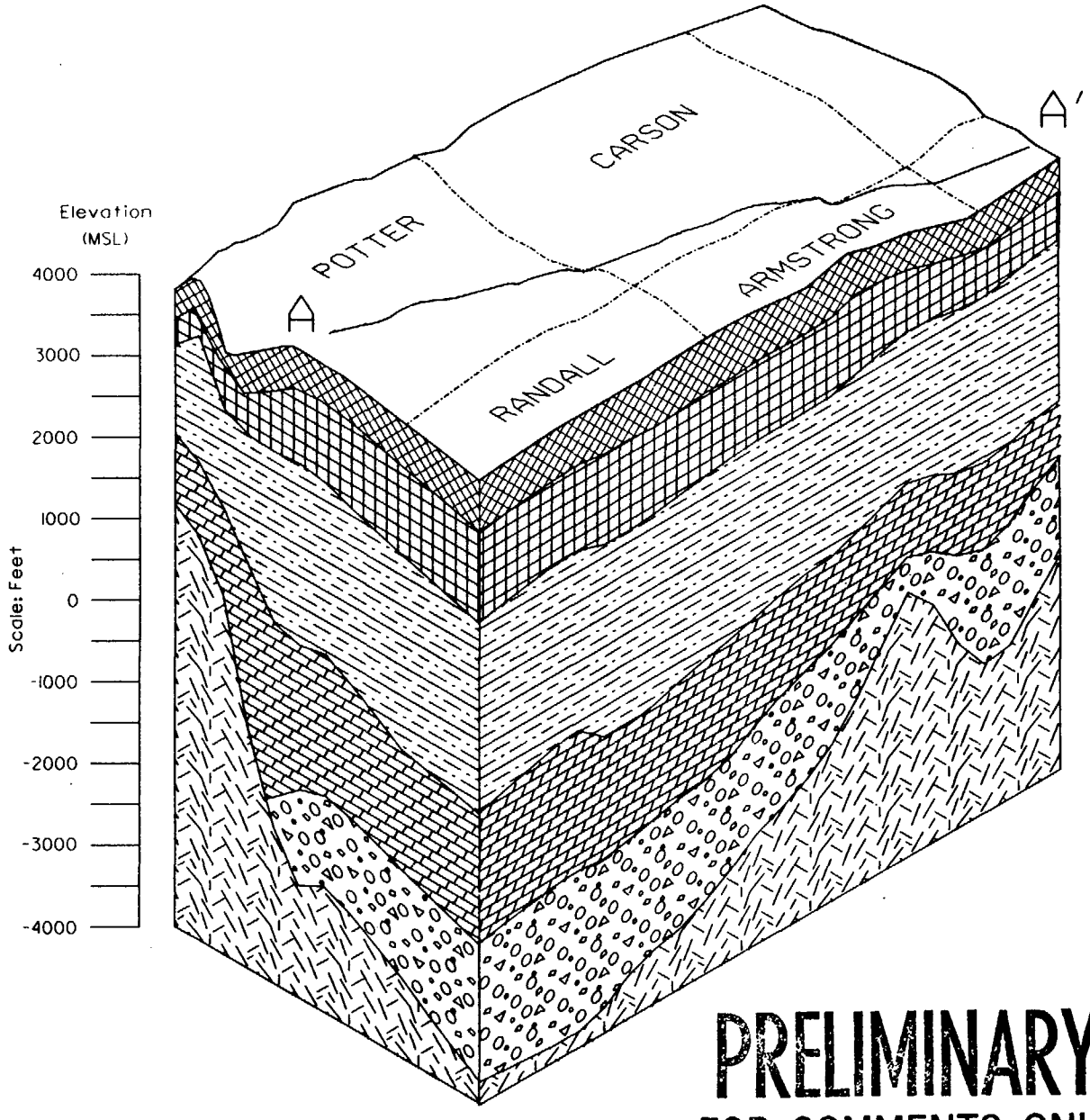
EXPLANATION

- County Line
- Cross Section Line (A — A')
- Alibates - Queen/Grayburg
- San Andres
- Glorieta - Wichita
- Wolfcamp
- Pennsylvanian
- Precambrian



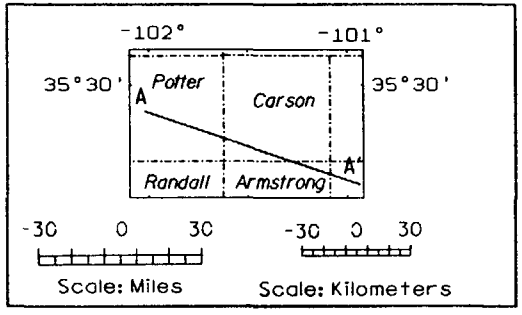
PRELIMINARY
FOR COMMENTS ONLY

Patterned Cross Section



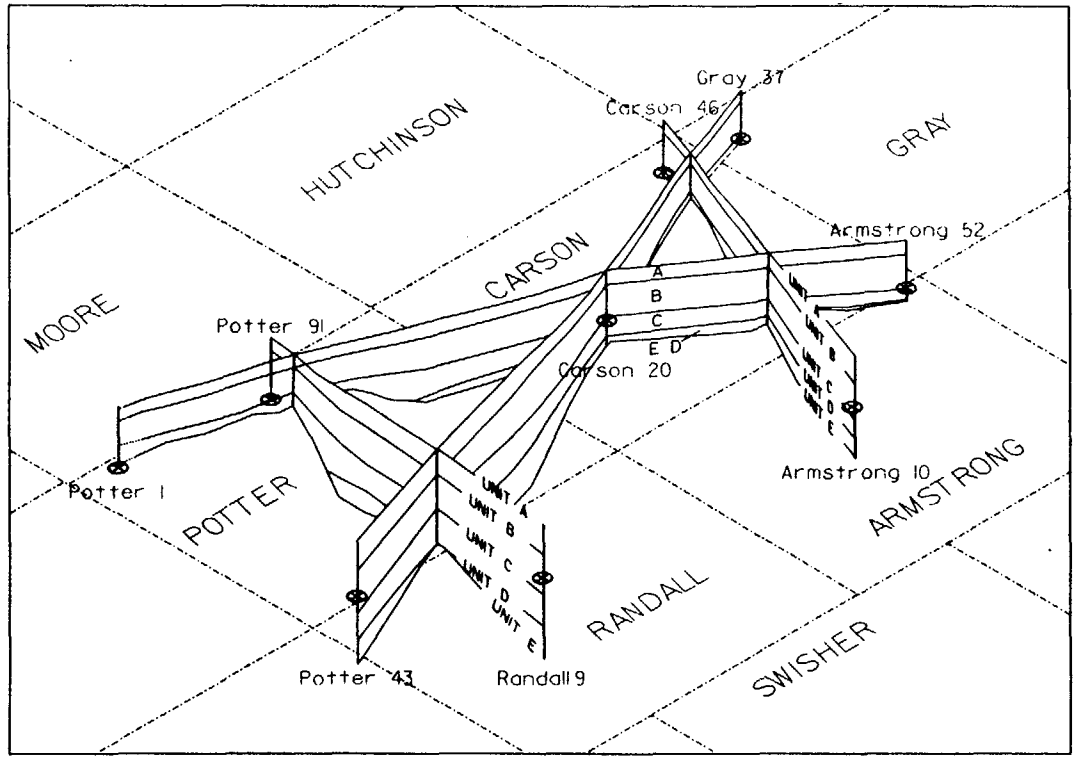
EXPLANATION

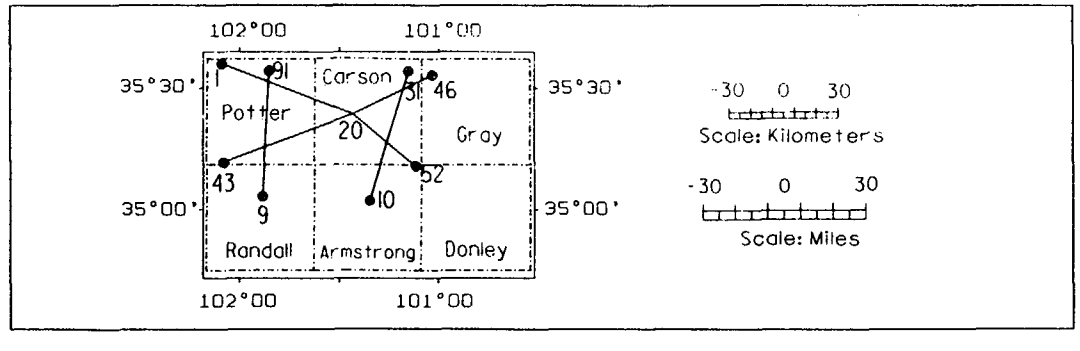
- County Line
- Cross Section Line
- Alibates - Queen/Grayburg
- San Andres
- Glorieta - Wichita
- Wolfcamp
- Pennsylvanian
- Precambrian



PRELIMINARY
FOR COMMENTS ONLY

Block Diagram





EXPLANATION

UNIT A: Alibates - San Andres

UNIT B: Glorieta - Wichita

UNIT C: Wolfcamp

UNIT D: Pennsylvanian

UNIT E: Precambrian

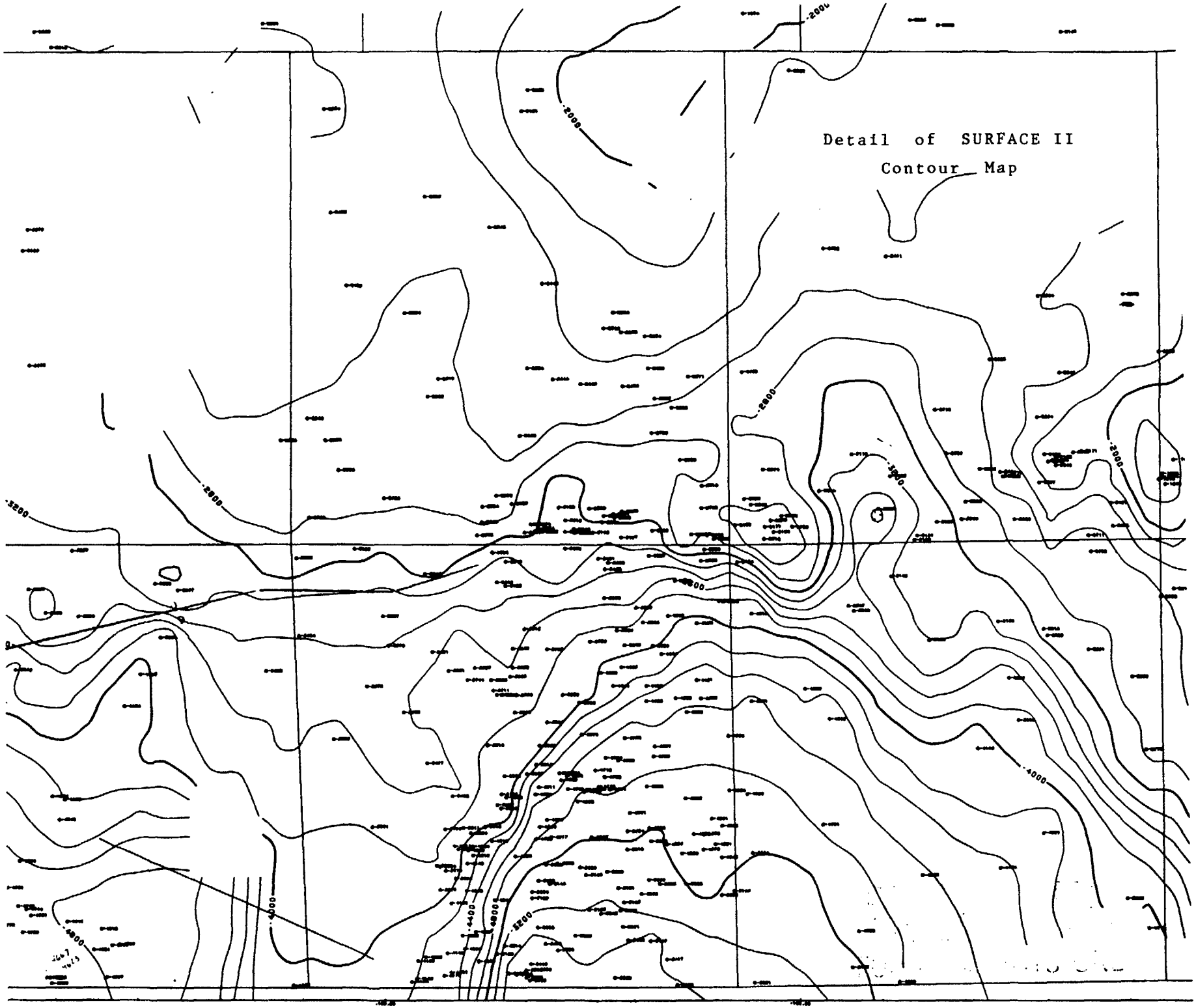
⊕ Well Symbol

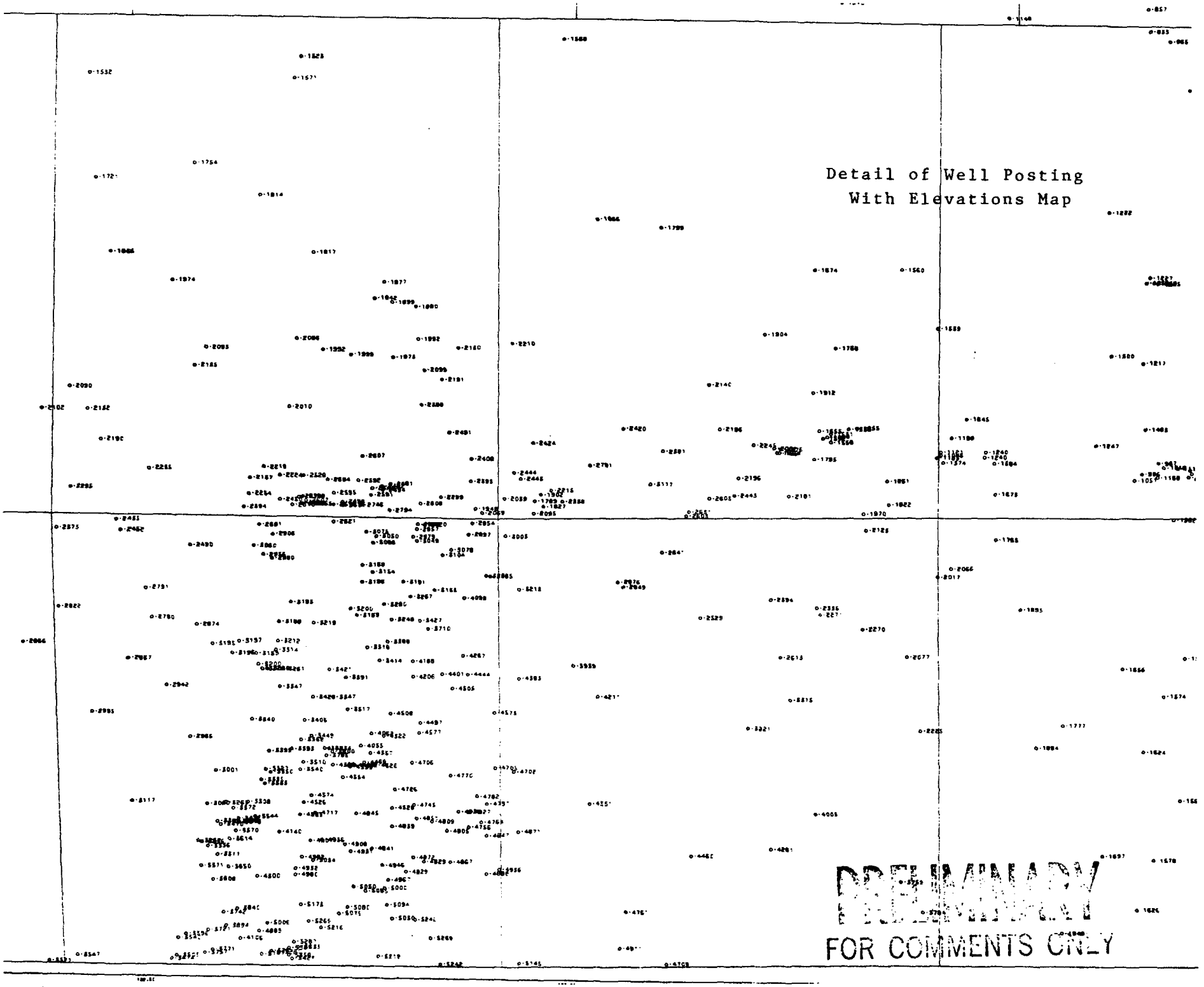
Note: Well symbols are at elevation 0 (MSL).

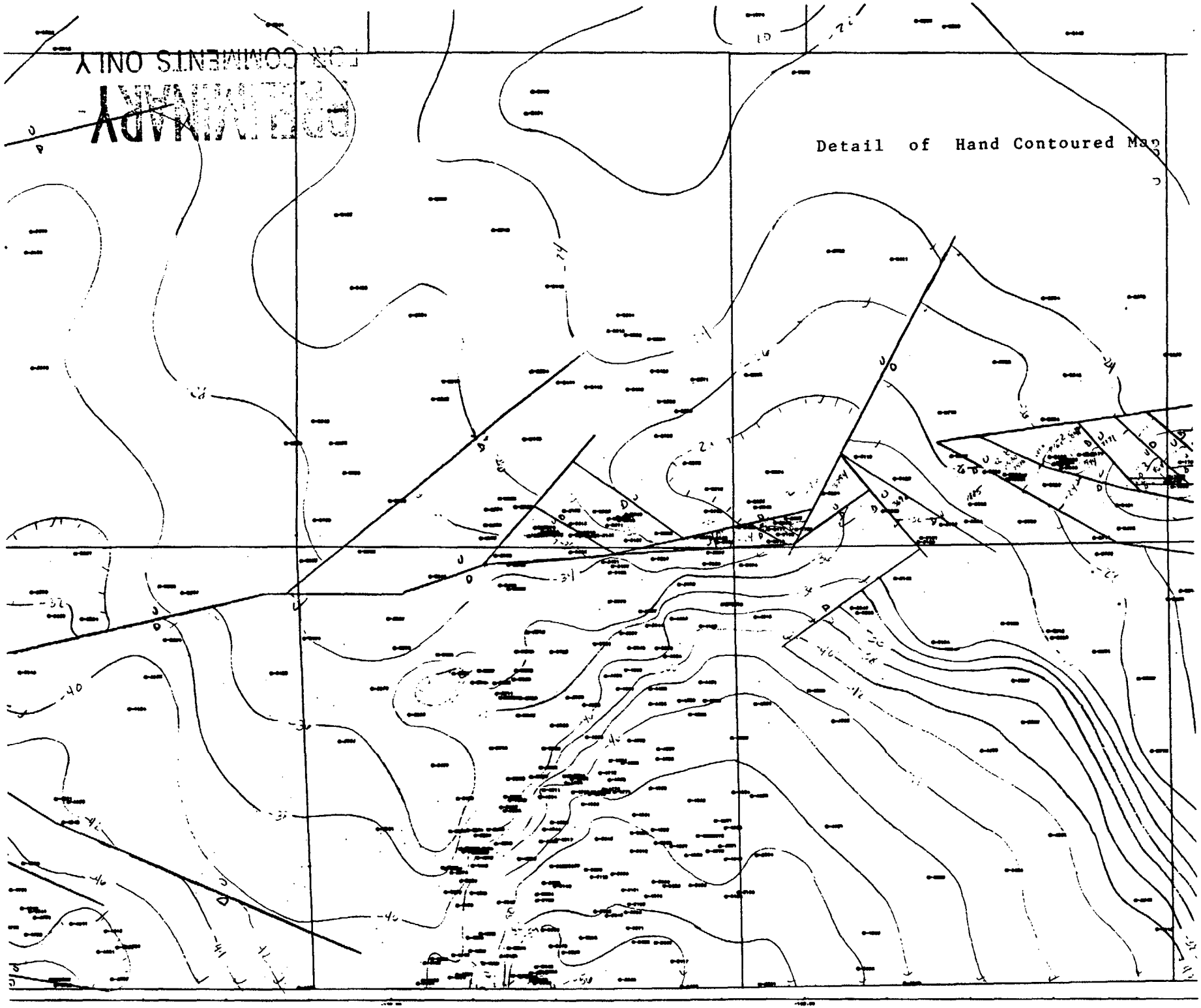
PRELIMINARY

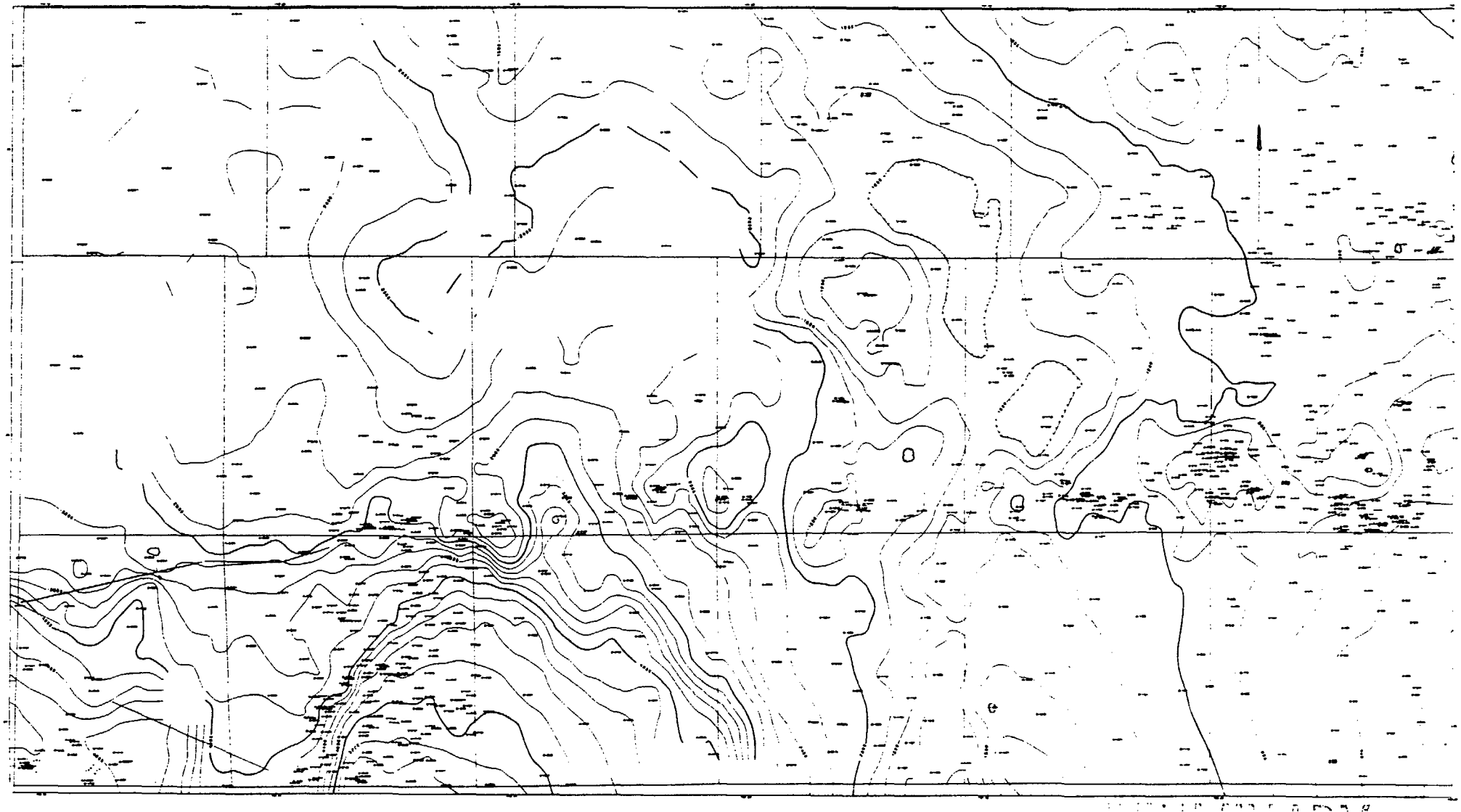
FOR COMMENTS ONLY

Fence Diagram

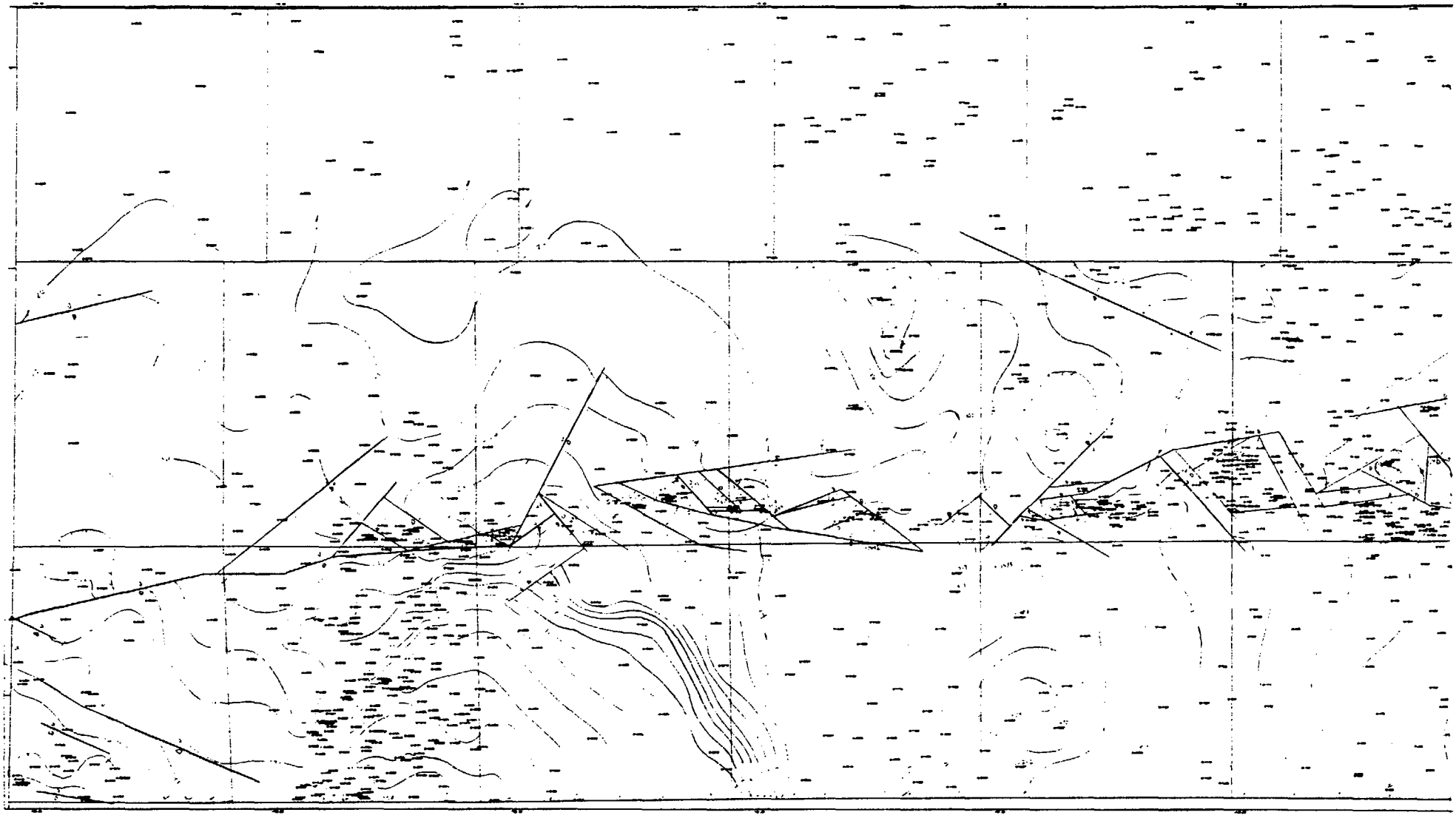

Detail of SURFACE II
Contour Map


Detail of Well Posting
With Elevations Map
PRELIMINARY
FOR COMMENTS ONLY


Detail of Hand Contoured Map



SURFACE II Contour Map

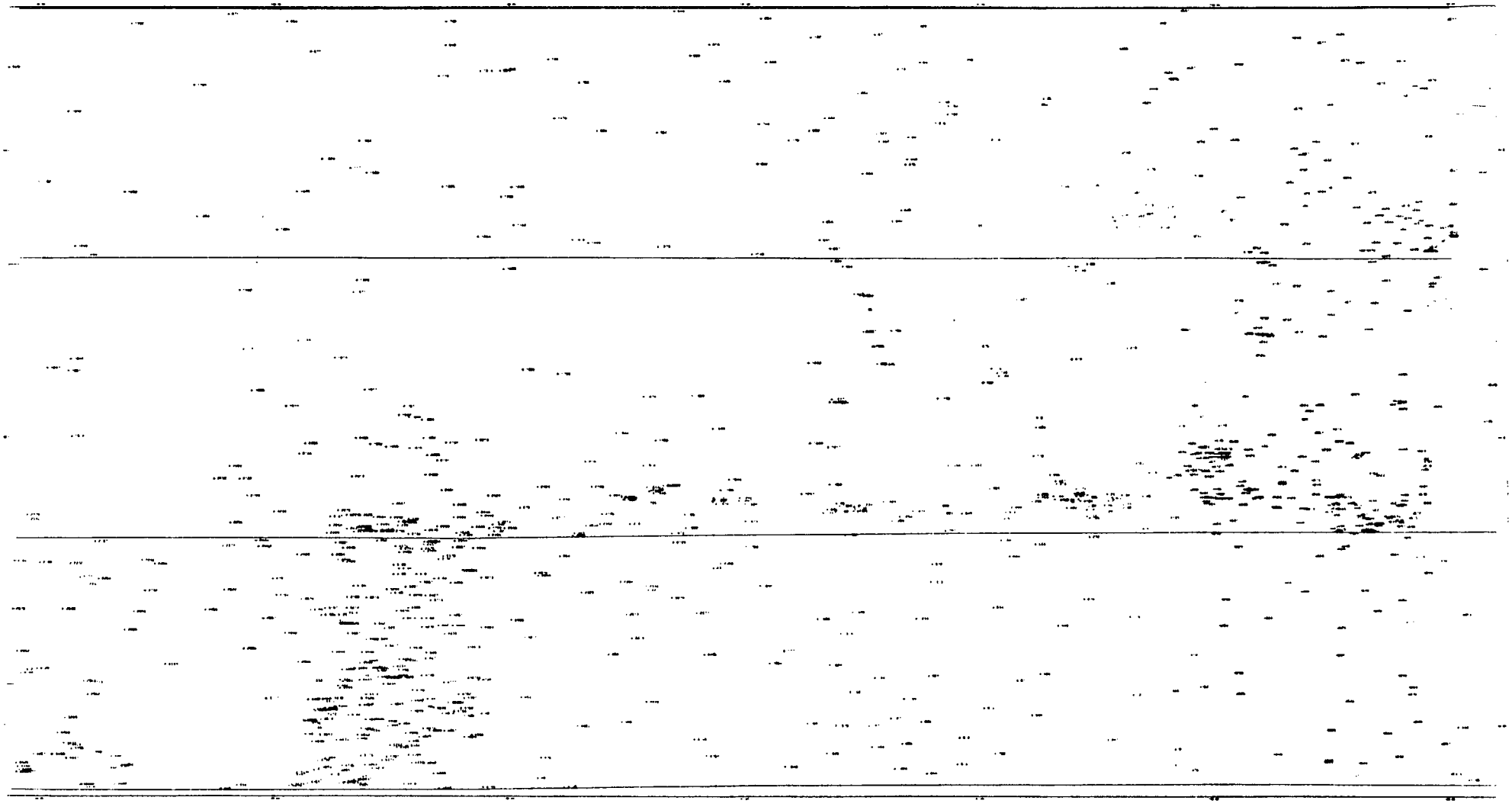


Hand Drawn Contour Map

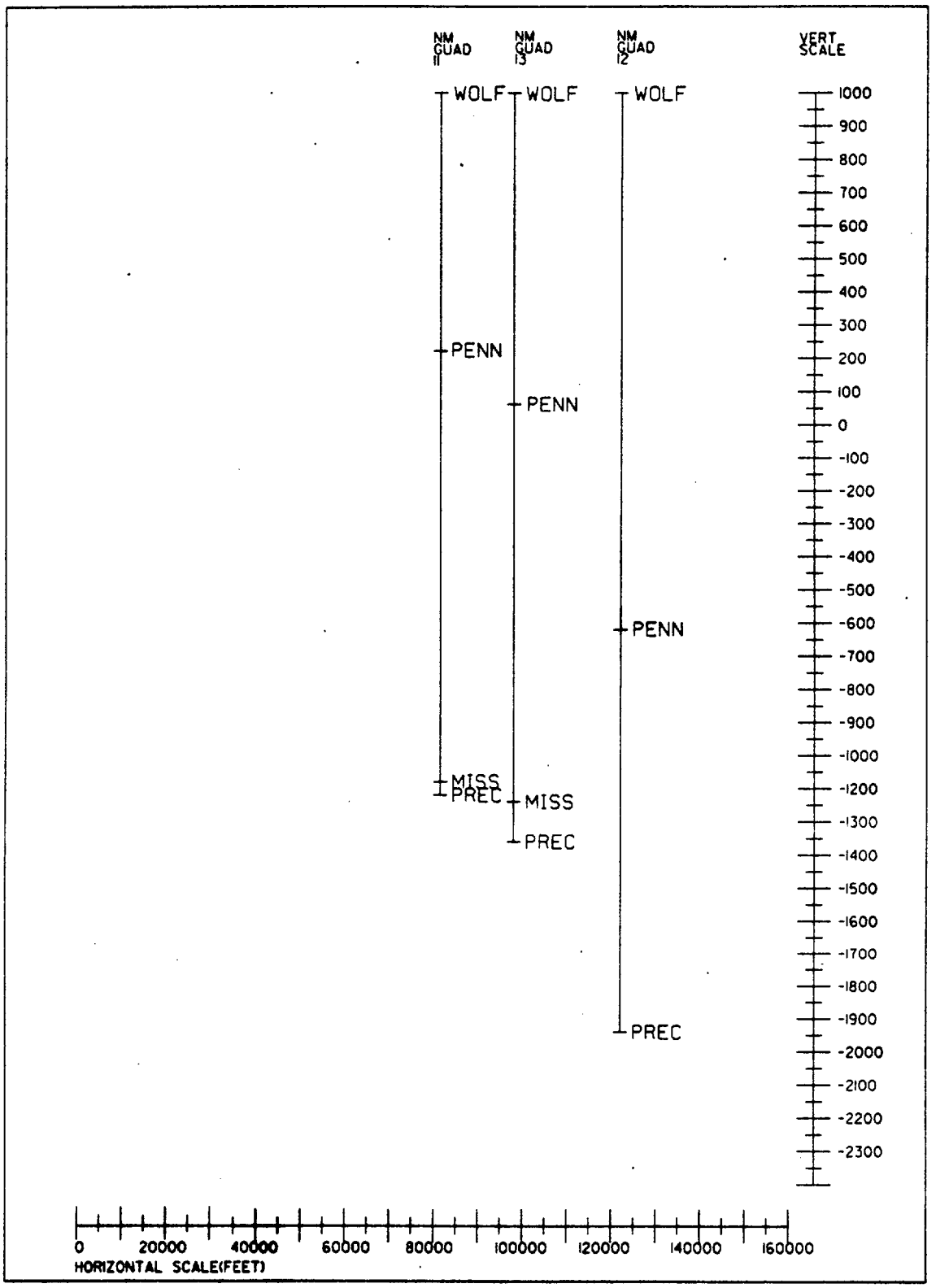
Based on SURFACE II Map

PRELIMINARY

FOR COMMENTS ONLY



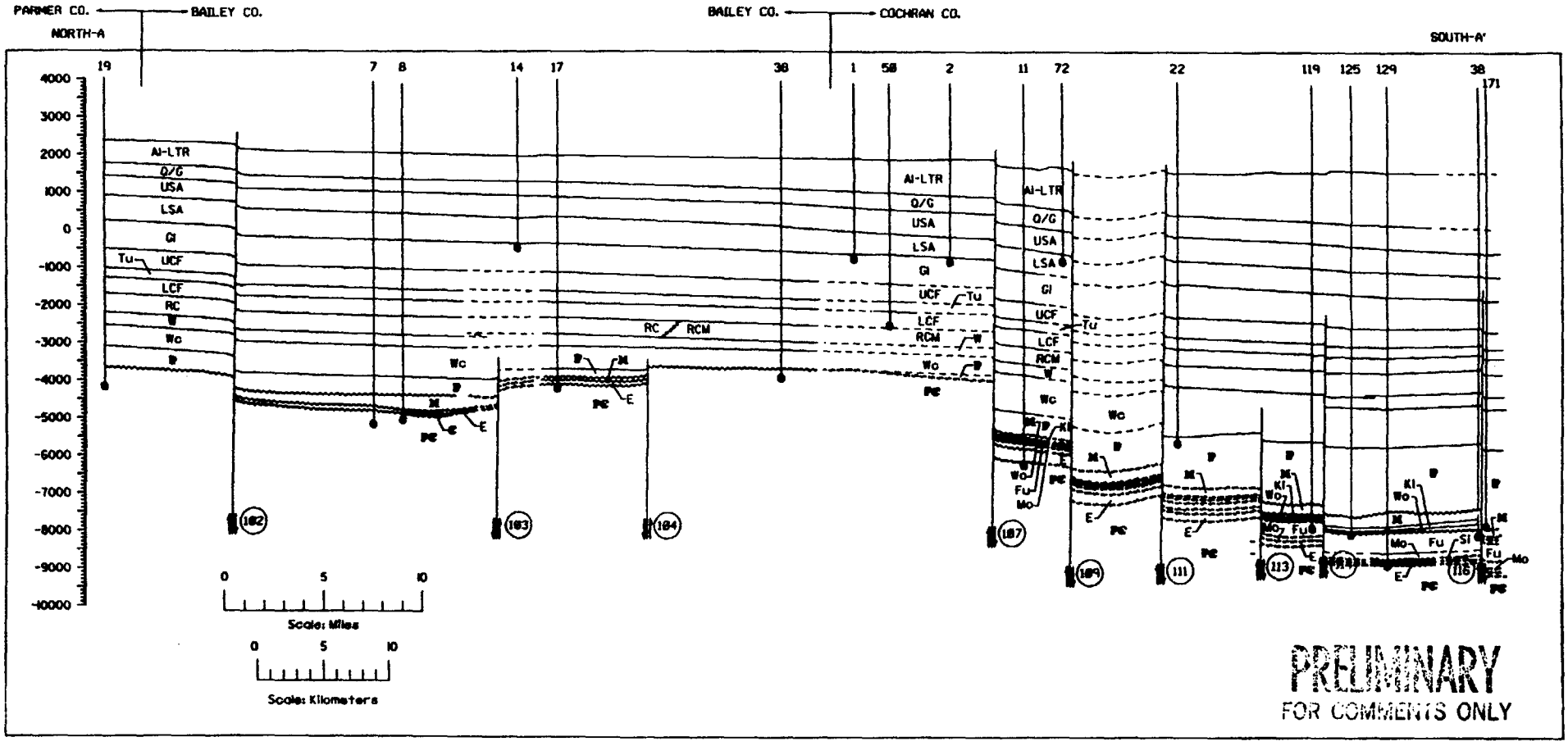
Well Posting Map with Z Values



PRELIMINARY

FOR COMMENTS ONLY

Example of WELLMAP Cross Section


PARMER CO.
BAILEY CO.
BAILEY CO.
COCHRAN CO.
NORTH-A
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Scale: Miles
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PRELIMINARY
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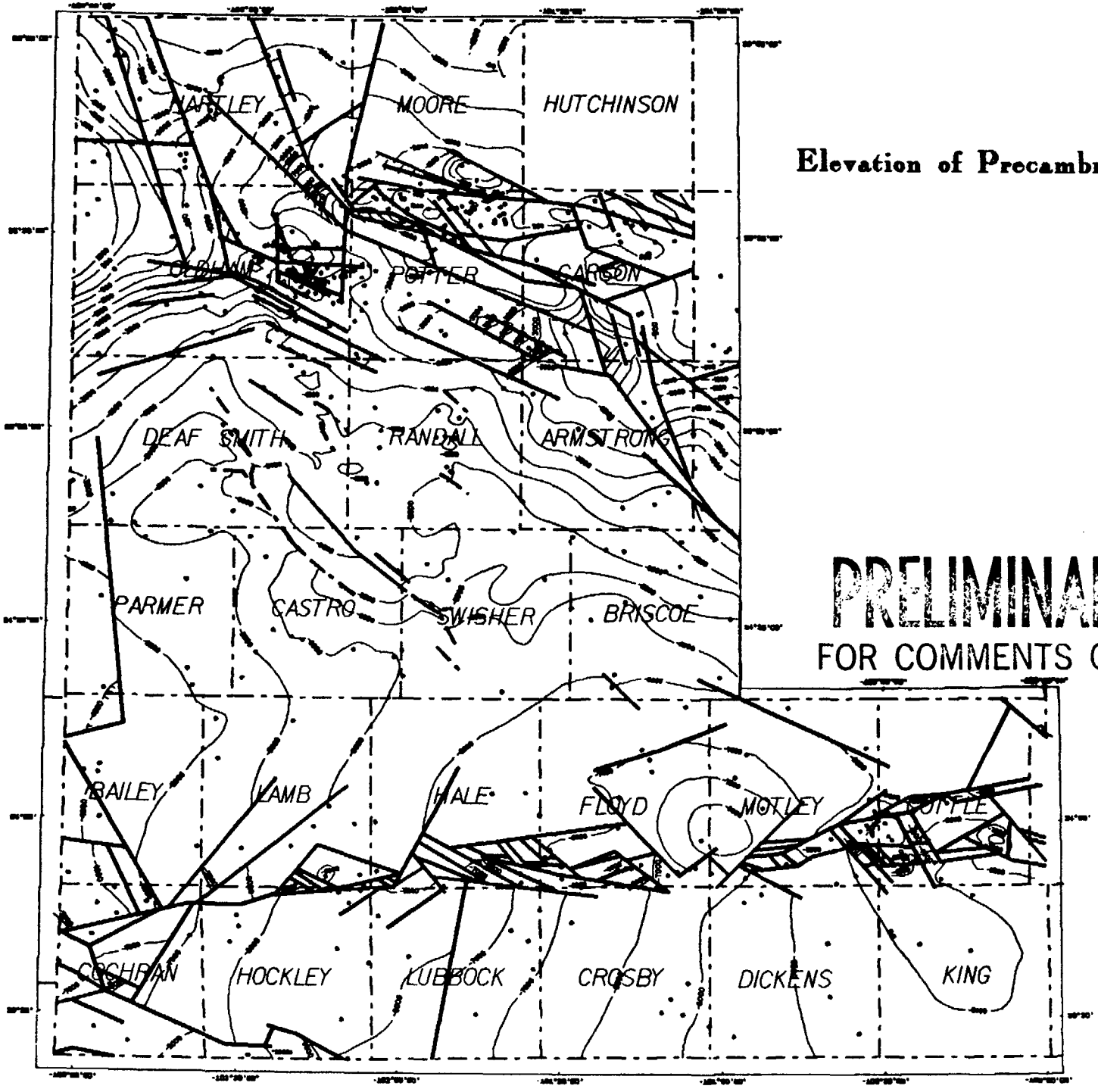


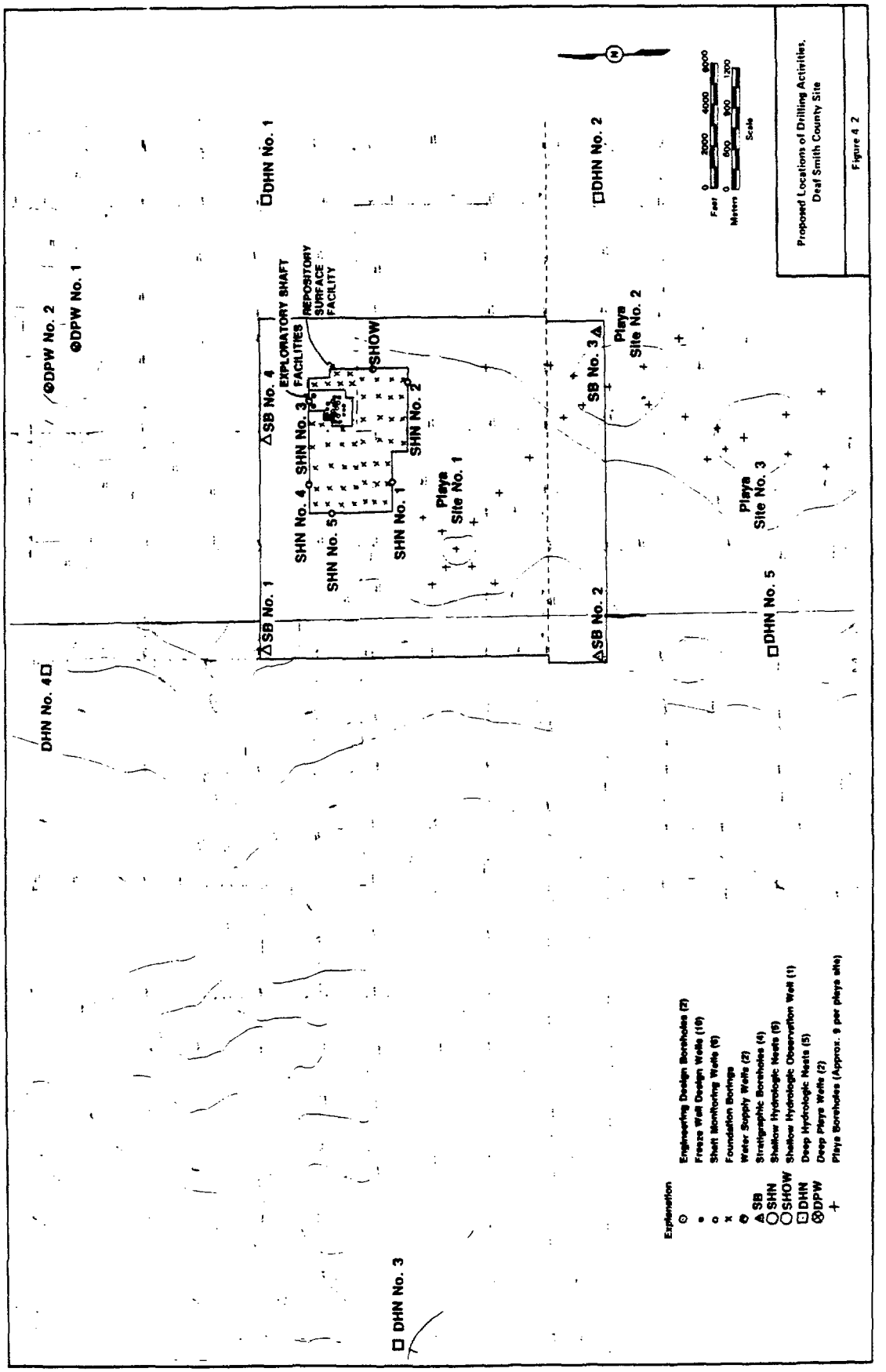
Elevation of Precambrian

PRELIMINARY

FOR COMMENTS ONLY

Ballmann (20)

A larger reproduction of this figure appears at the back of this volume.



Enclosure 4

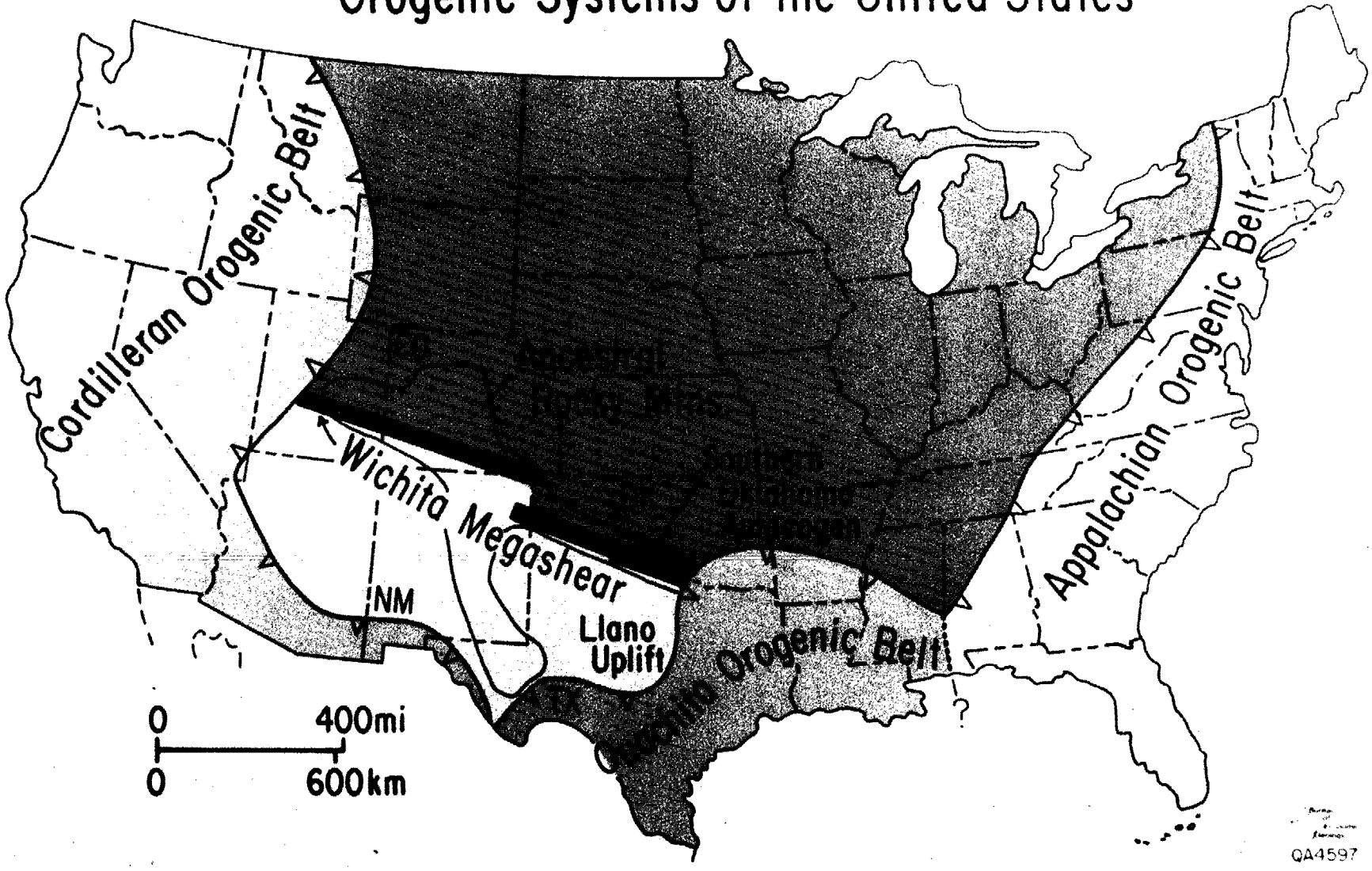
Seismic Reflection Survey Data
Reviewed by NRC

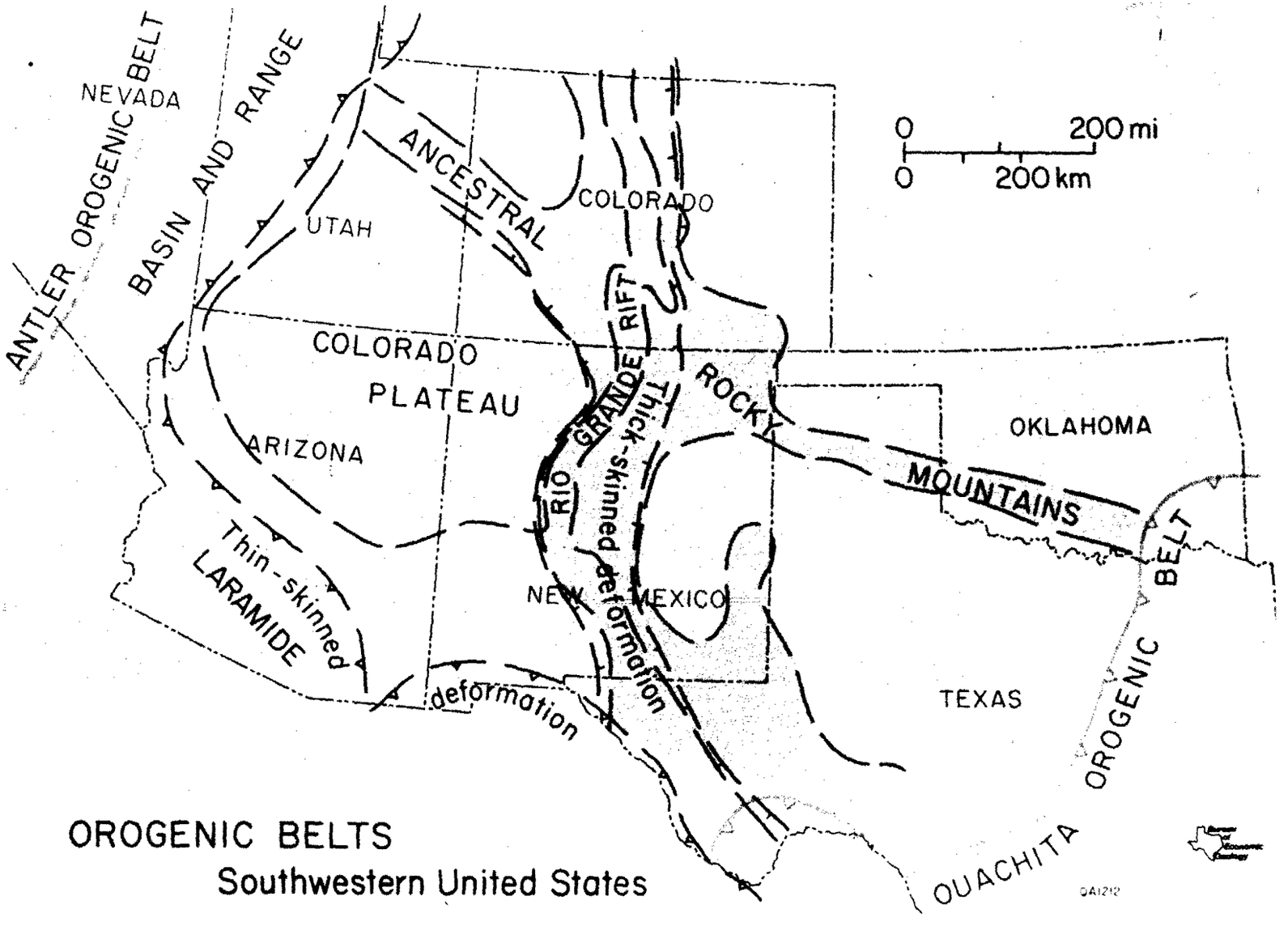
Seismic survey data of a proprietary nature were reviewed by the NRC staff and contractors. These consisted of the following lines designated on SWEC drawing "Sketch No. 13697-44-A-1":

STM-PD-10
STM-PD-11
STM-PD-9
GEO-E
W-95

0240C

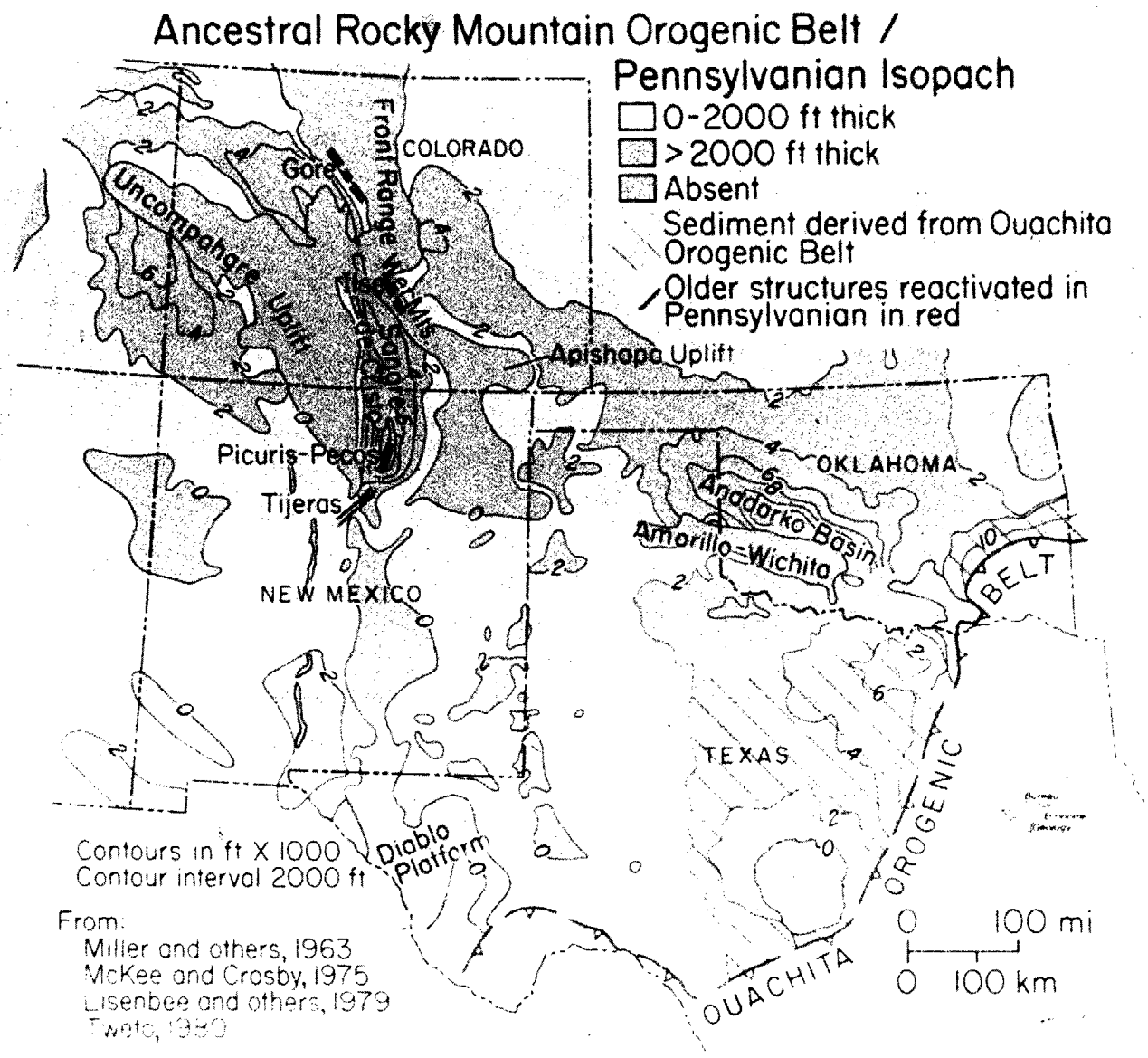
Orogenic Systems of the United States

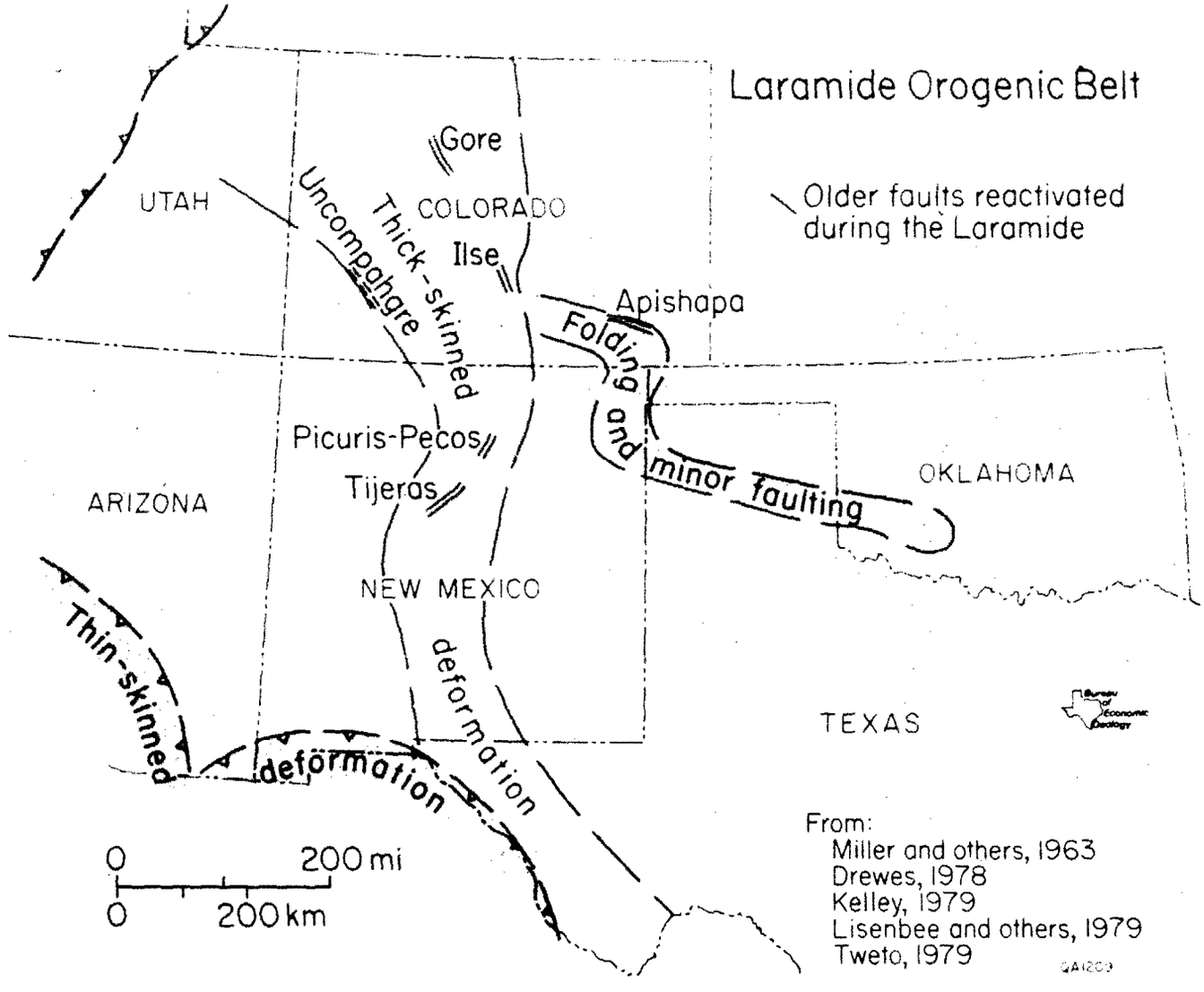




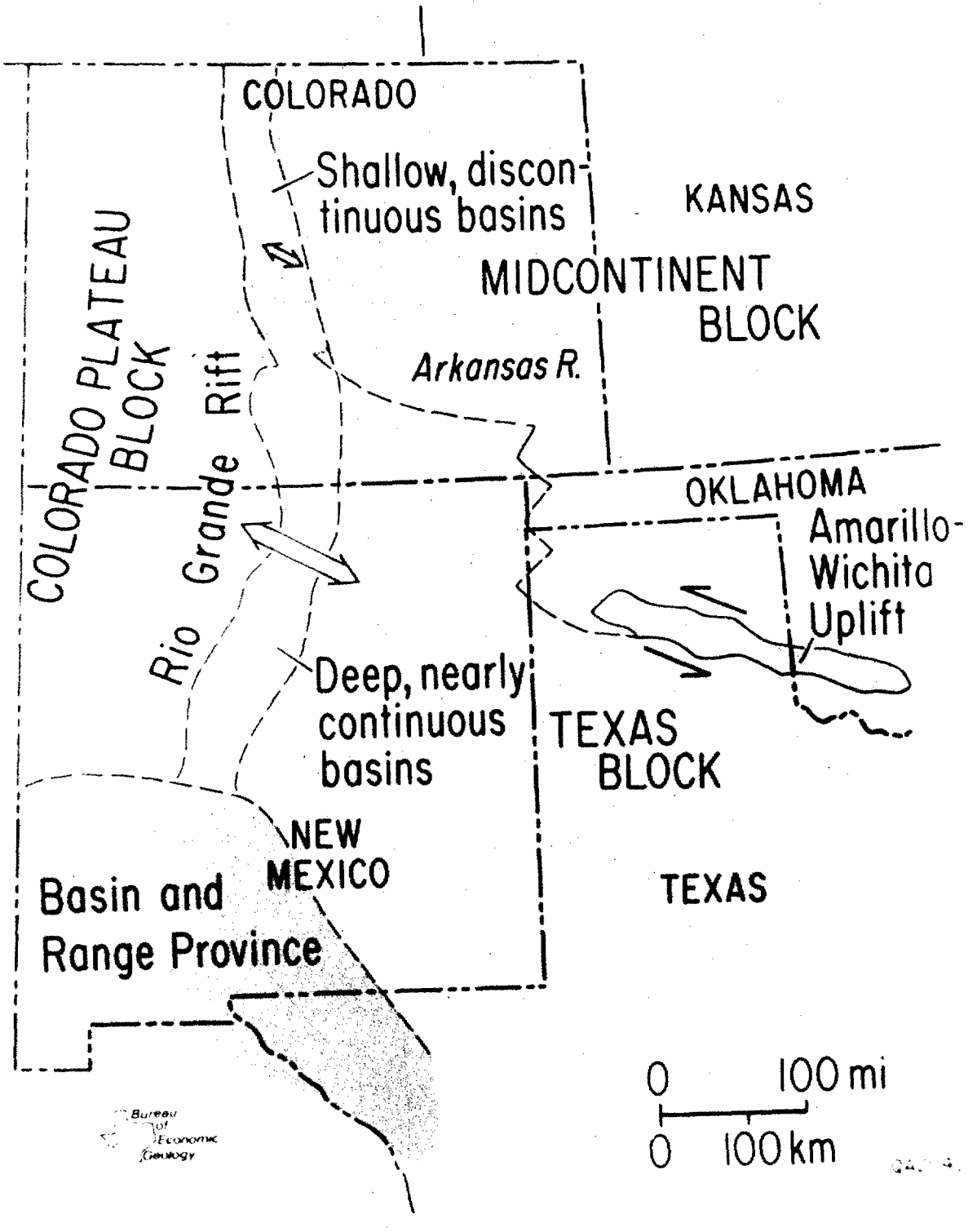
OROGENIC BELTS

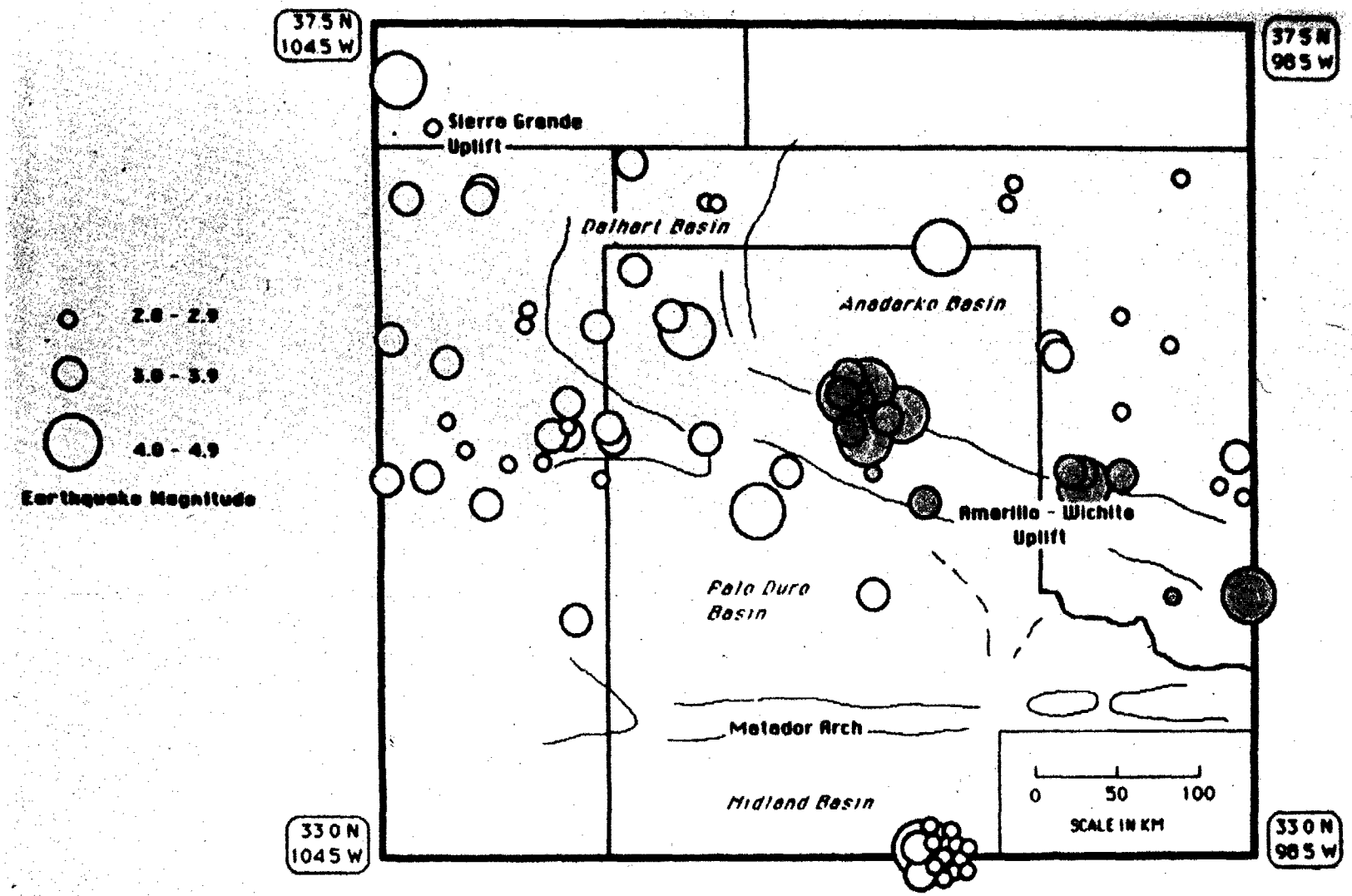
Southwestern United States


Ancestral Rocky Mountain Orogenic Belt /
Pennsylvanian Isopach
0-2000 ft thick
>2000 ft thick
Absent
Sediment derived from Ouachita Orogenic Belt
Older structures reactivated in Pennsylvanian in red
COLORADO
Gore
Front Range
Uncompahgre Uplift
Apishapa Uplift
Picuris-Pecos
Tijeras
NEW MEXICO
OKLAHOMA
Anadarko Basin
Amarillo-Wichita
BELT
TEXAS
Diablo Platform
OUACHITA OROGENIC
Contours in ft X 1000
Contour interval 2000 ft
From:
Miller and others, 1963
McKee and Crosby, 1975
Eisenbee and others, 1979
Tweto, 1980
0 100 mi
0 100 km

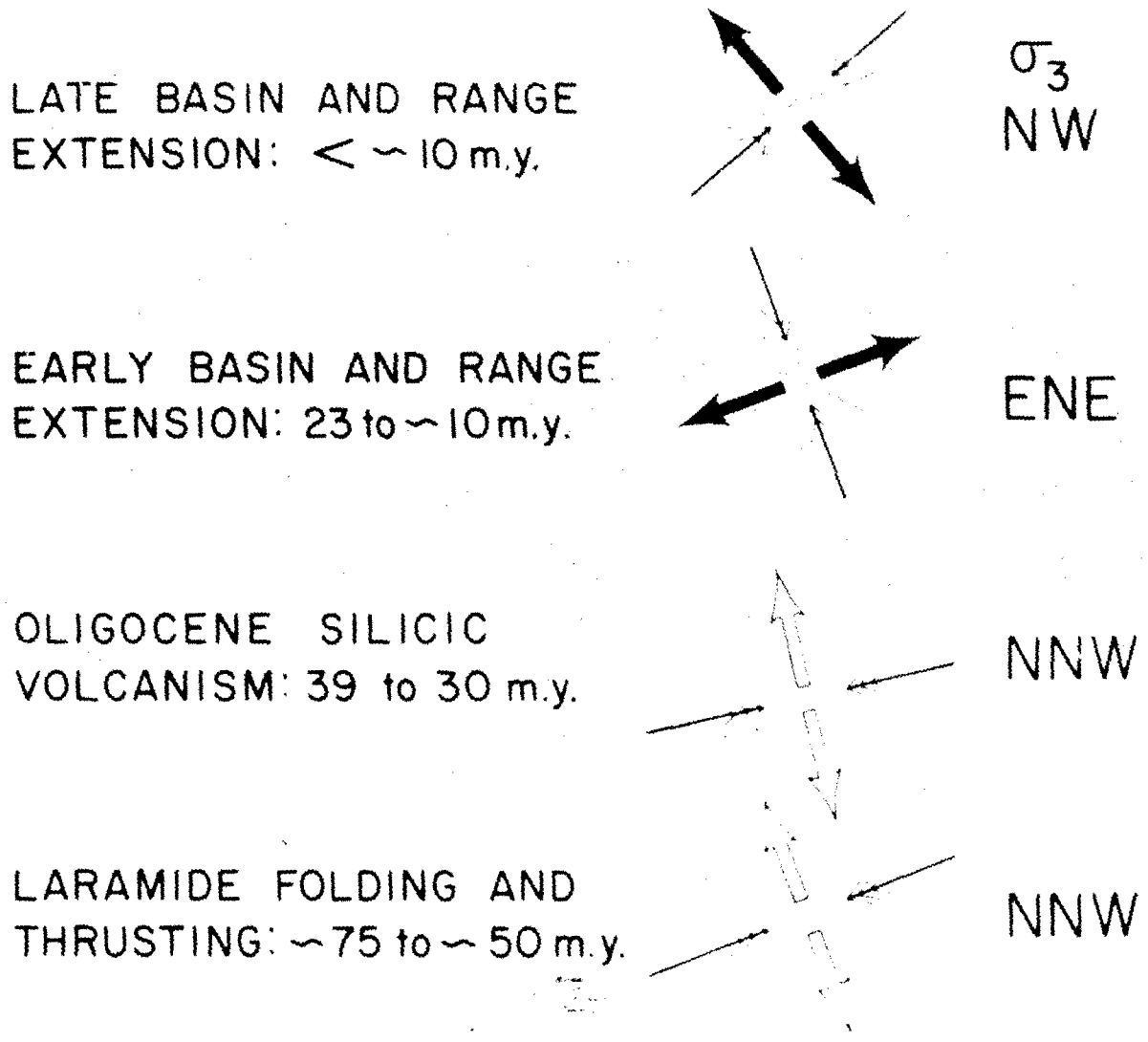

Laramide Orogenic Belt
Older faults reactivated during the Laramide
Gore
UTAH
COLORADO
Uncompahgre
Thick-skinned
Ilse
Apishapa
Folding and minor faulting
Picuris-Pecos
Tijeras
ARIZONA
OKLAHOMA
NEW MEXICO
Thin-skinned deformation
deformation
TEXAS
0 200 mi
0 200 km
From:
Miller and others, 1963
Drewes, 1978
Kelley, 1979
Lisenbee and others, 1979
Tweto, 1979

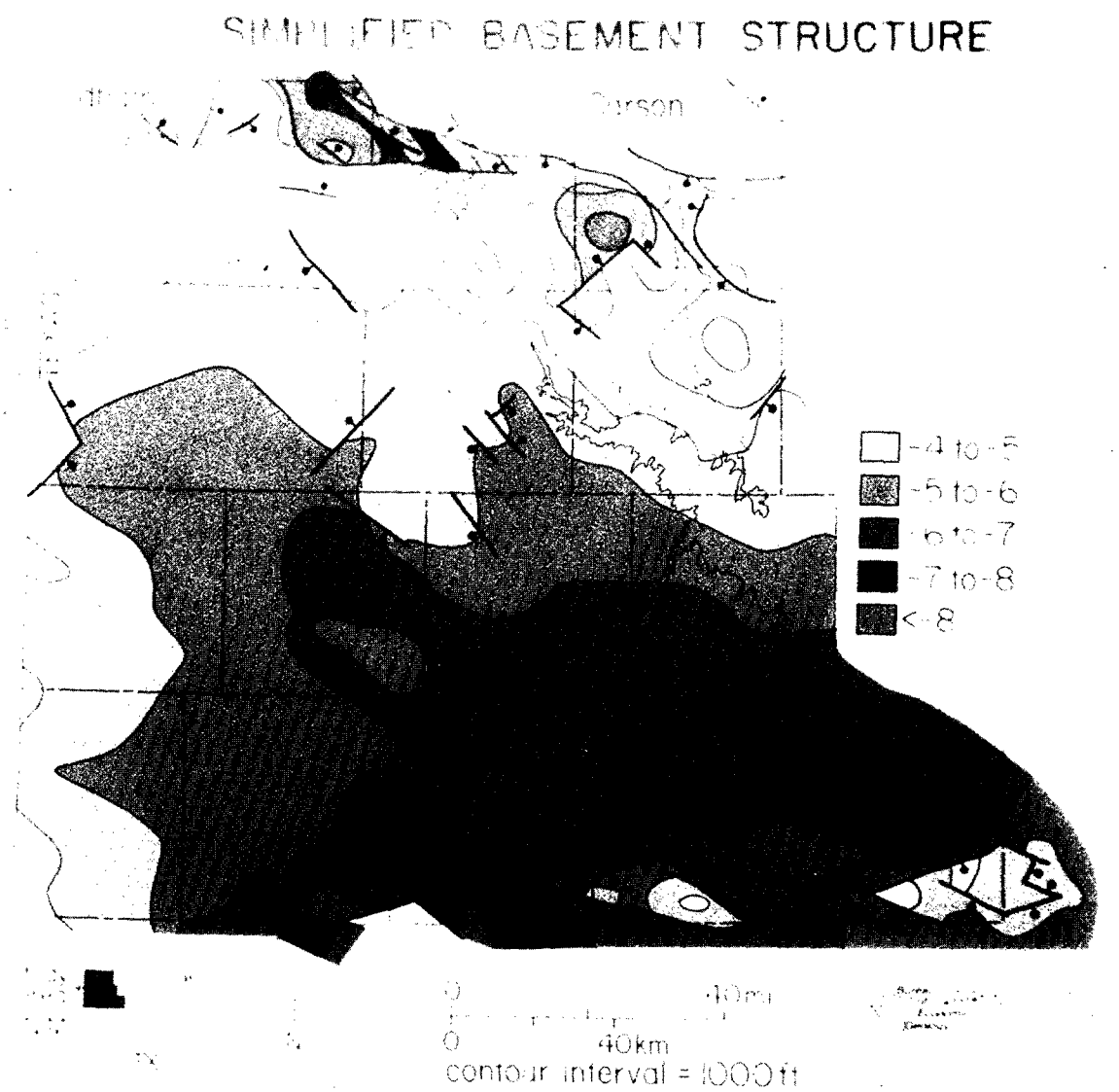
NEOGENE TECTONIC SETTING




37.5 N
104.5 W
37.5 N
98.5 W
Sierra Grande
Uplift
Dalhart Basin
Anadarko Basin
Amarillo - Wichita
Uplift
Palo Duro
Basin
Matador Arch
Midland Basin
33.0 N
104.5 W
33.0 N
98.5 W
0
50
100
SCALE IN KM
2.0 - 2.9
3.0 - 3.9
4.0 - 4.9
Earthquake Magnitude


SANGRE DE CRISTO UPLIFT
SIERRA GRANDE ARCH
OKLAHOMA
SACRAMENTO UPLIFT
PLATFORM
OUACHITA

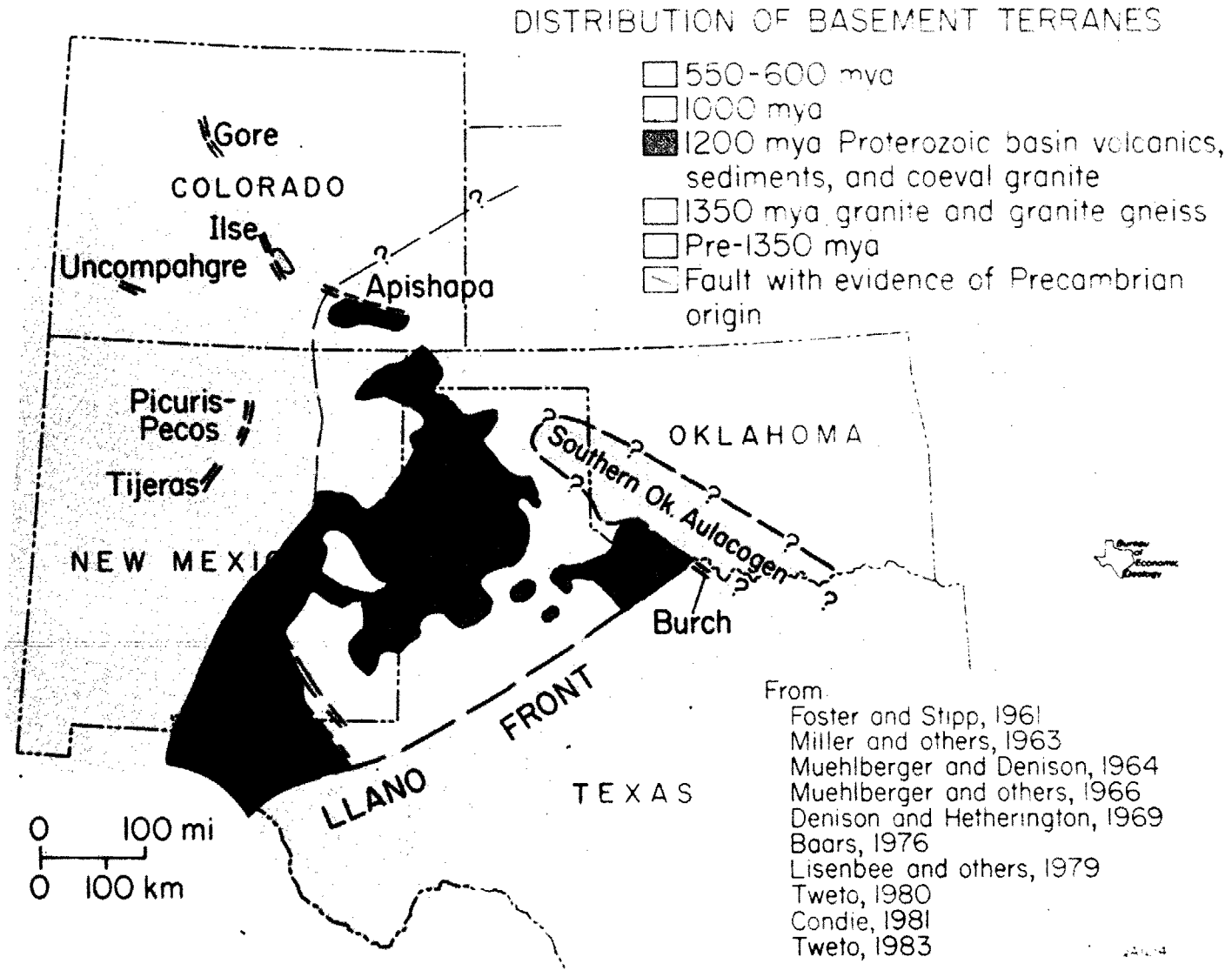

LATE BASIN AND RANGE
EXTENSION: < ~ 10 m.y.
σ_3
NW
EARLY BASIN AND RANGE
EXTENSION: 23 to ~ 10 m.y.
ENE
OLIGOCENE SILICIC
VOLCANISM: 39 to 30 m.y.
NNW
LARAMIDE FOLDING AND
THRUSTING: ~ 75 to ~ 50 m.y.
NNW



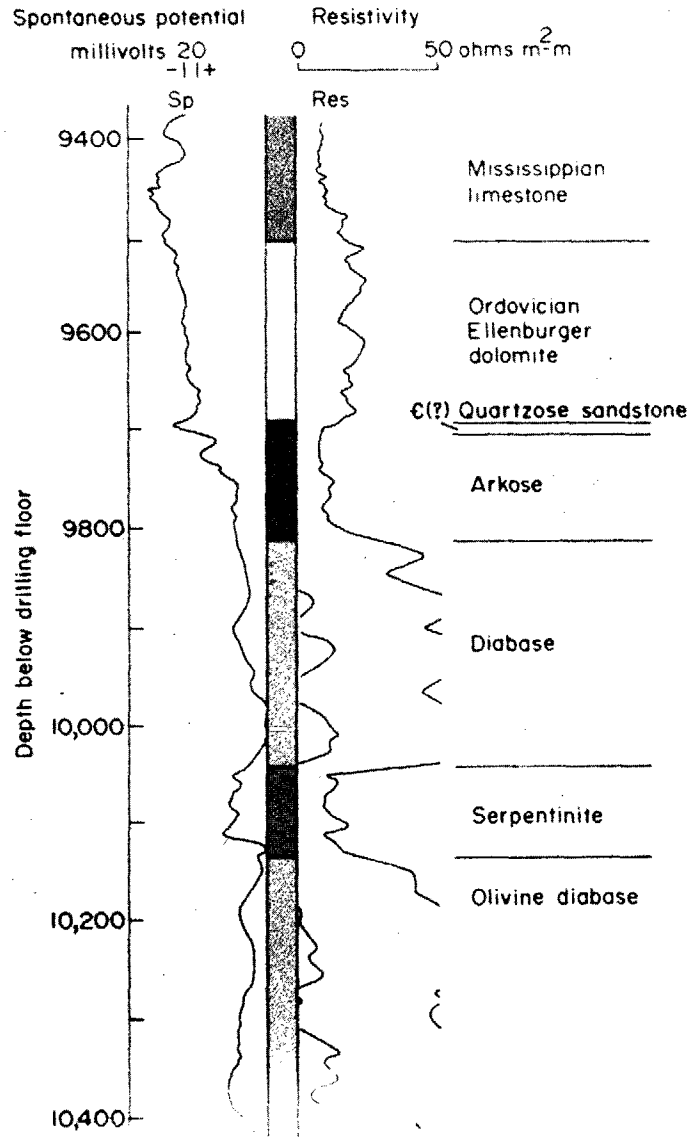
EXPLANATION (ft X 1000)

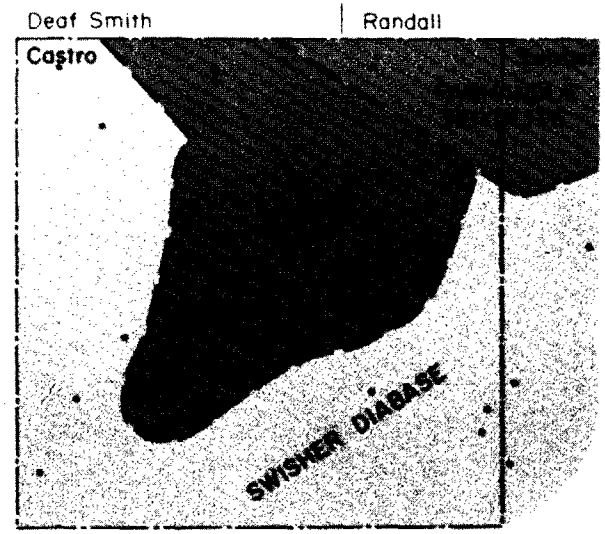
(from Budnik, 1984)

>1	0 to -1	-2 to -3	
1 to 0	-1 to -2	-3 to -4	


DISTRIBUTION OF BASEMENT TERRANES
550-600 mya
1000 mya
1200 mya Proterozoic basin volcanics, sediments, and coeval granite
1350 mya granite and granite gneiss
Pre-1350 mya
Fault with evidence of Precambrian origin
Gore
COLORADO
Ilse
Uncompahgre
Apishapa
Picuris-Pecos
Tijeras
NEW MEXICO
OKLAHOMA
Southern Ok. Aulacogen
Burch
LLANO
FRONT
TEXAS
0 100 mi
0 100 km
From
Foster and Stipp, 1961
Miller and others, 1963
Muehlberger and Denison, 1964
Muehlberger and others, 1966
Denison and Hetherington, 1969
Baars, 1976
Lisenbee and others, 1979
Tweto, 1980
Condie, 1981
Tweto, 1983

SUN OIL COMPANY #1 *Herring*, Castro County



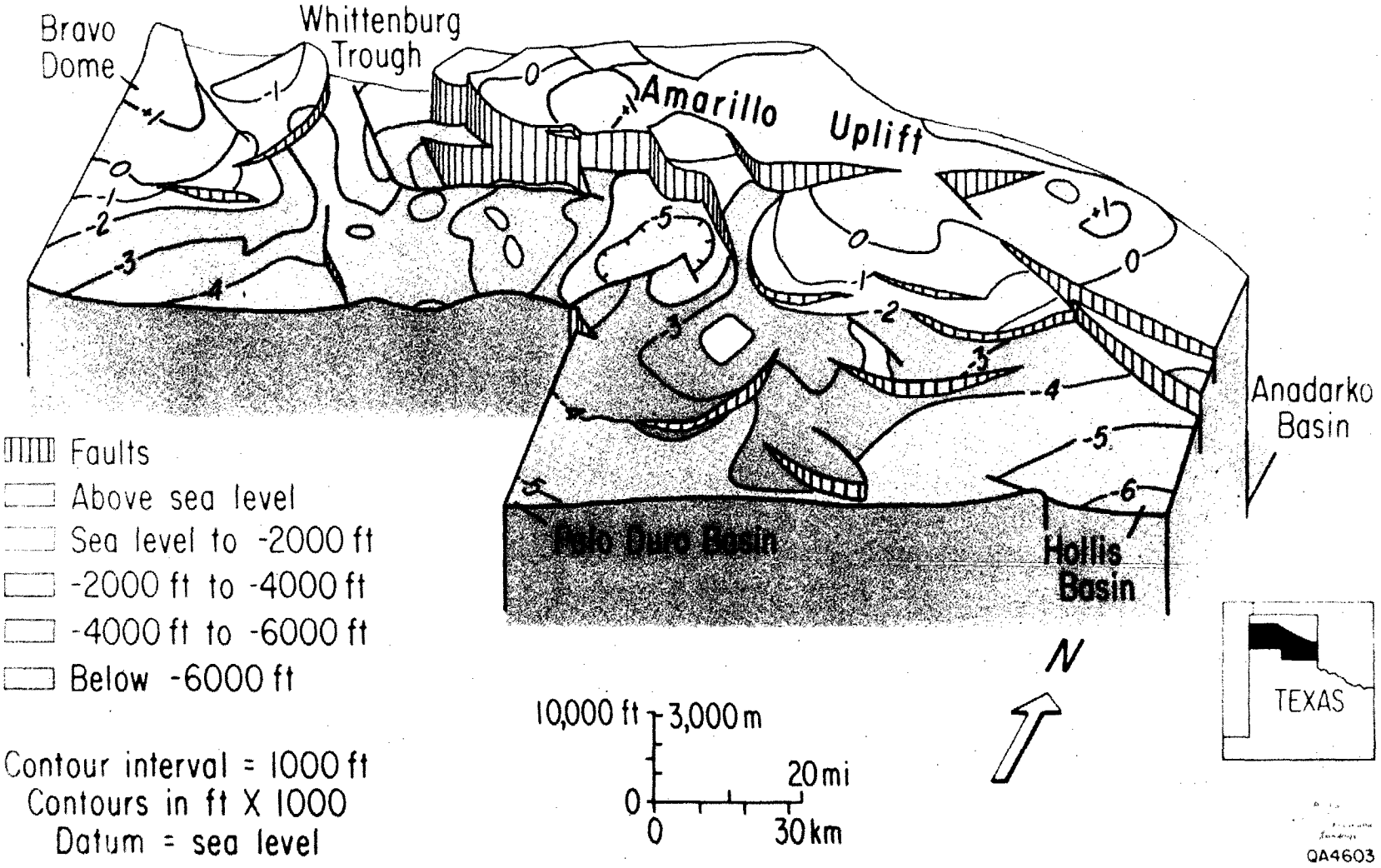


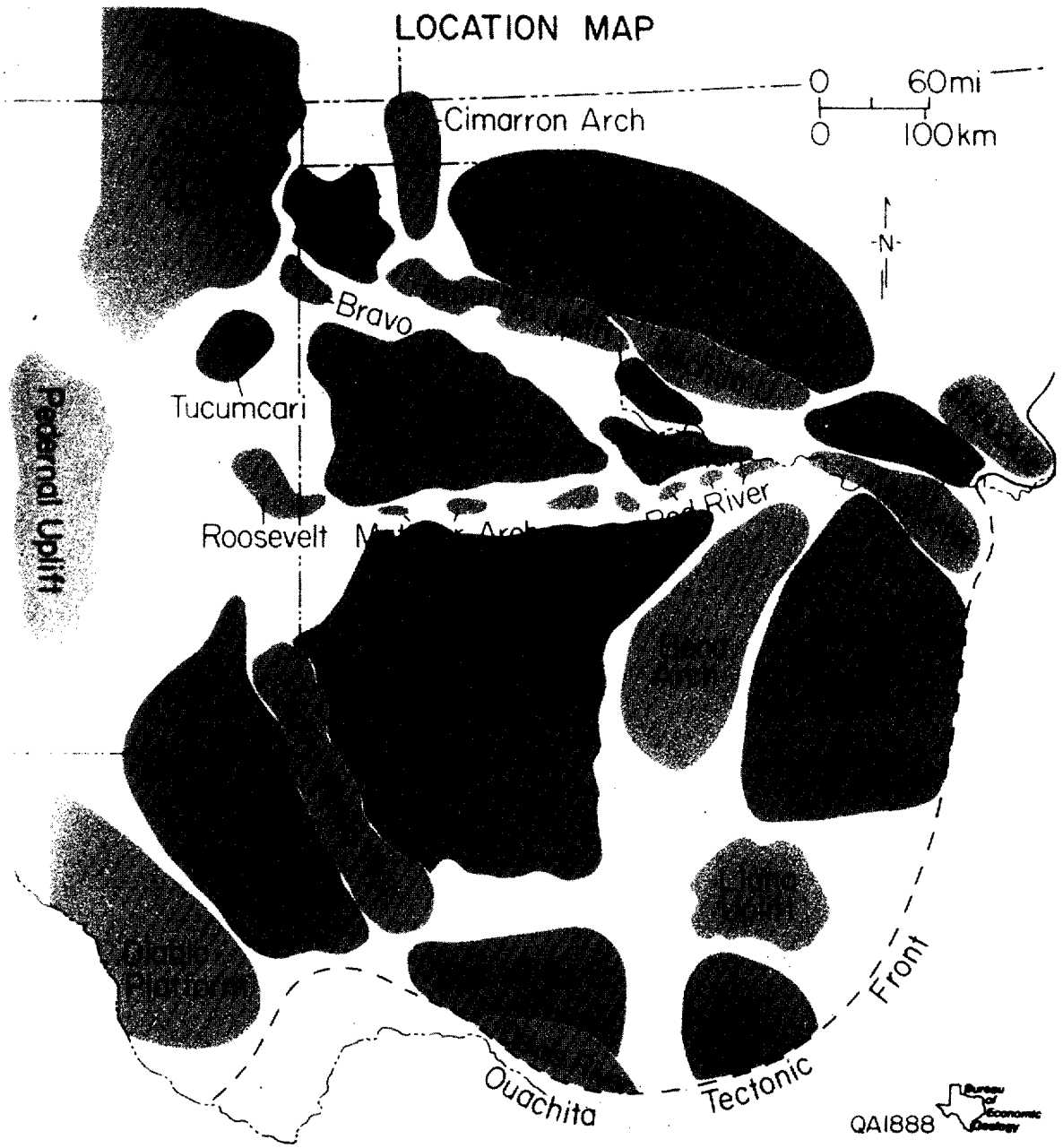
Distribution of pre-Ellenburger Group arkose in Castro Trough

- Well control
- ⊙ Wells penetrating pre-Ellenburger arkose

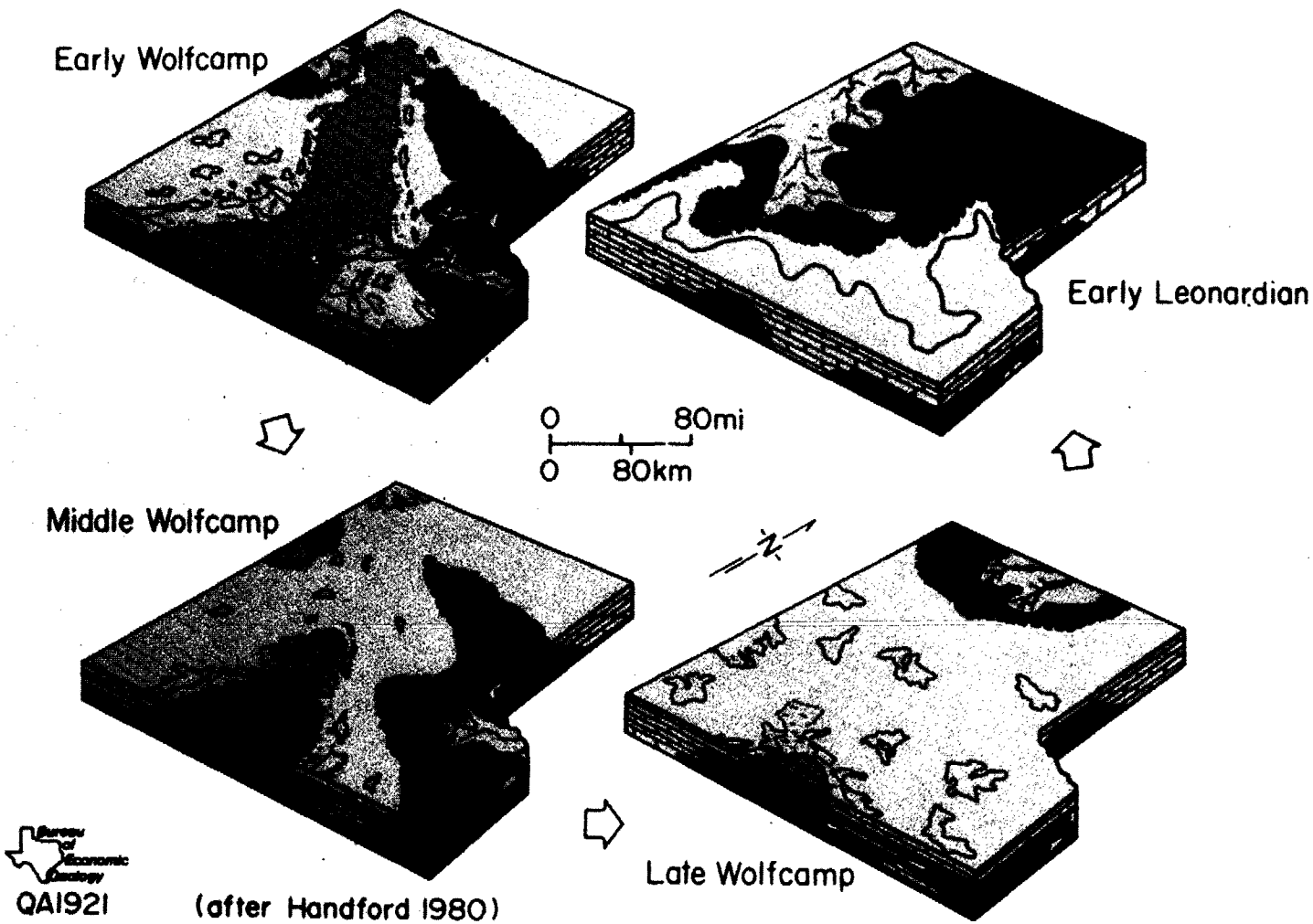
0 10 mi
0 10 km

Block diagram of basement surface of Amarillo Uplift



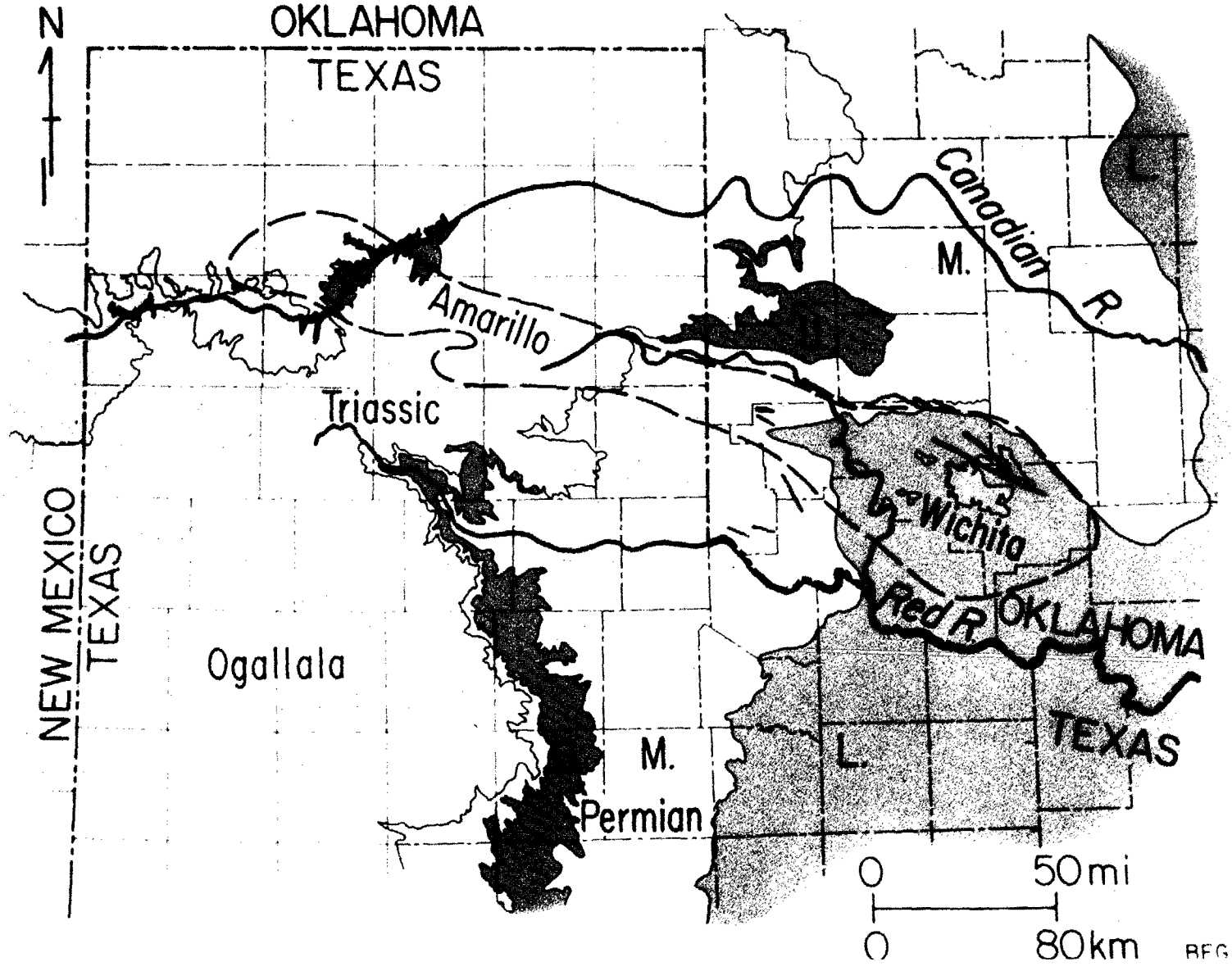

LOCATION MAP
0 60mi
0 100km
Cimarron Arch
N
Bravo
Tucumcari
Roosevelt
Red River
Pedernal Uplift
Front
Tectonic
Ouachita
QA1888

PALEOGEOGRAPHIC EVOLUTION OF PALO DURO BASIN

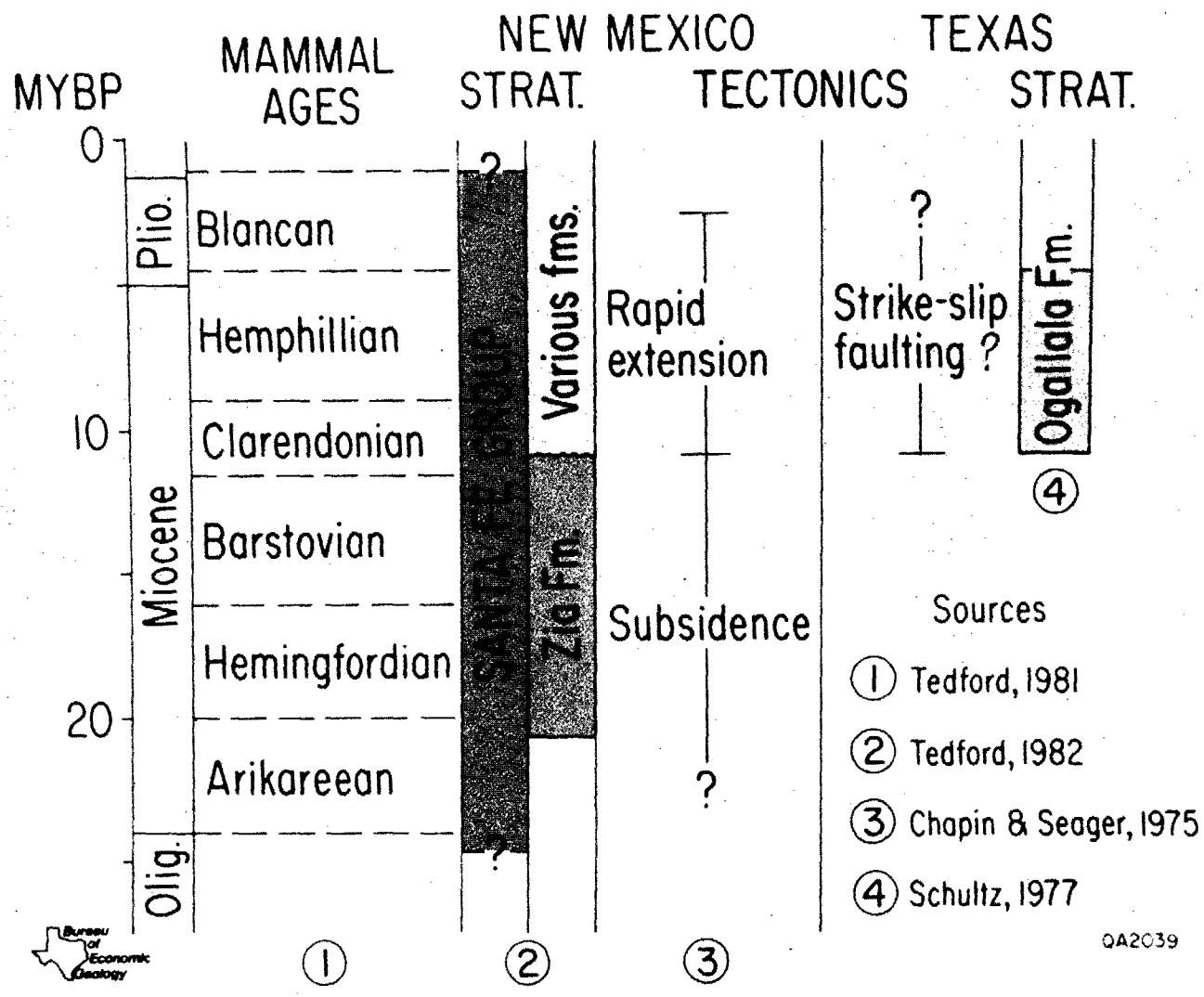


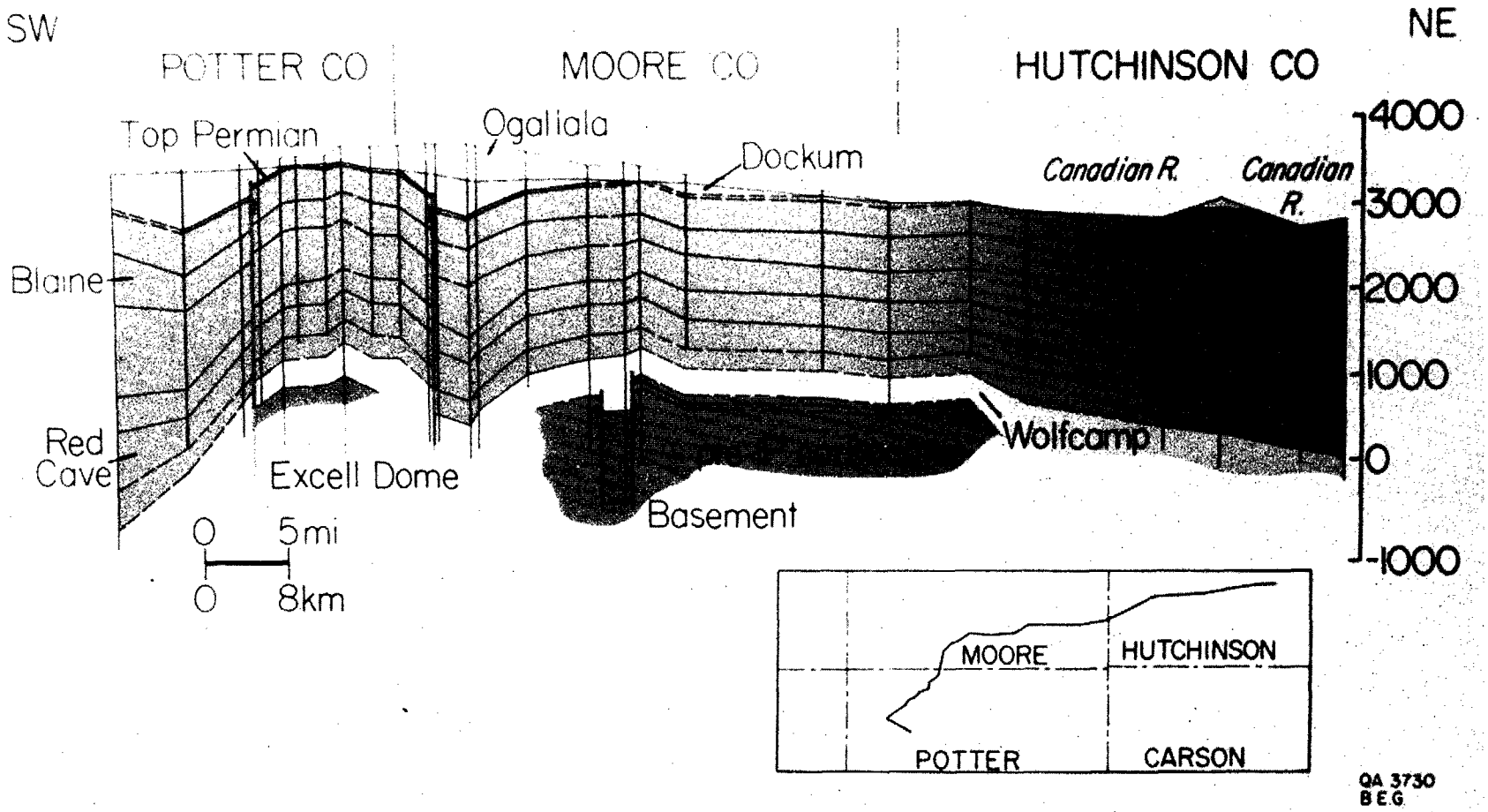
QA1921

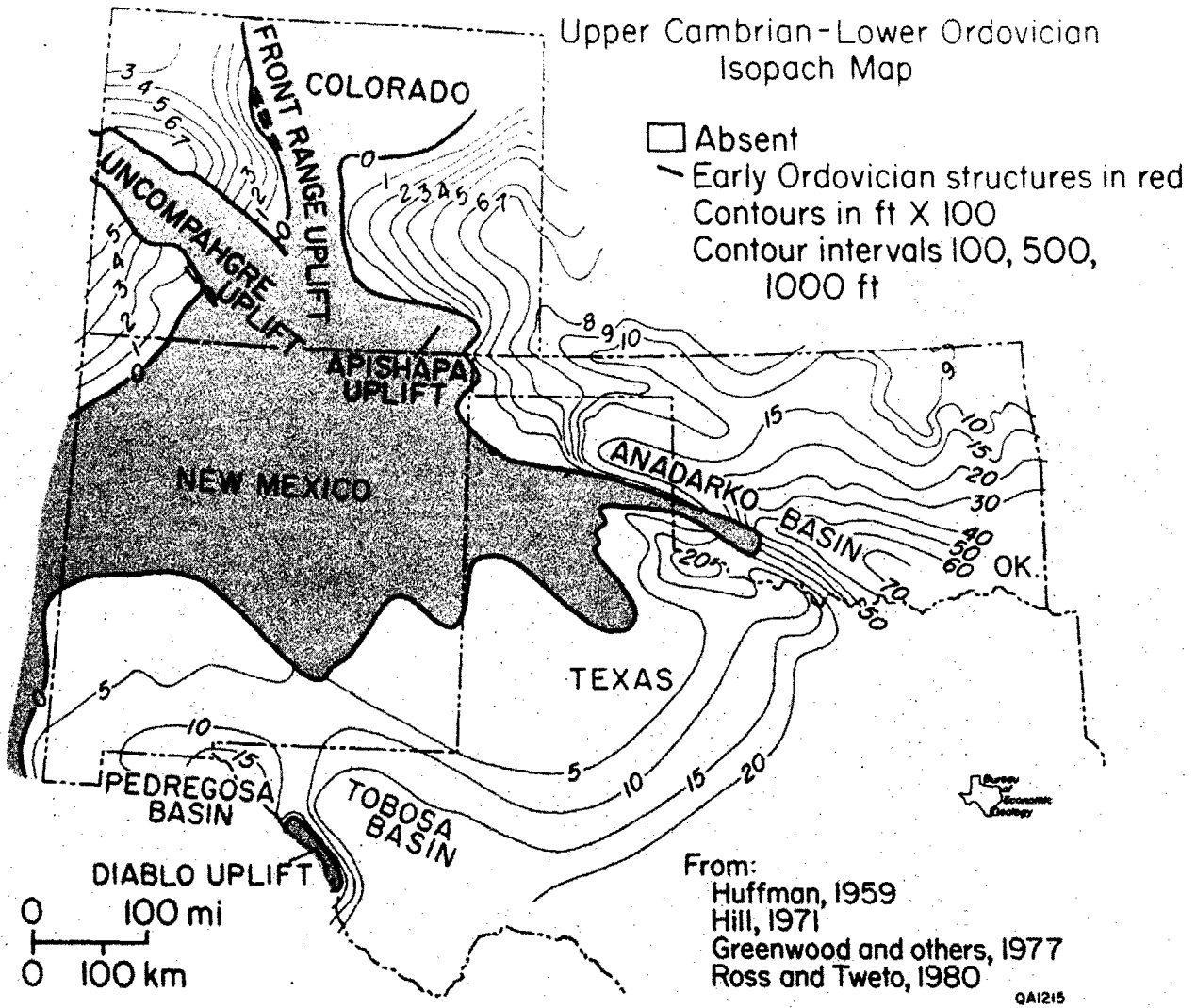
(after Handford 1980)

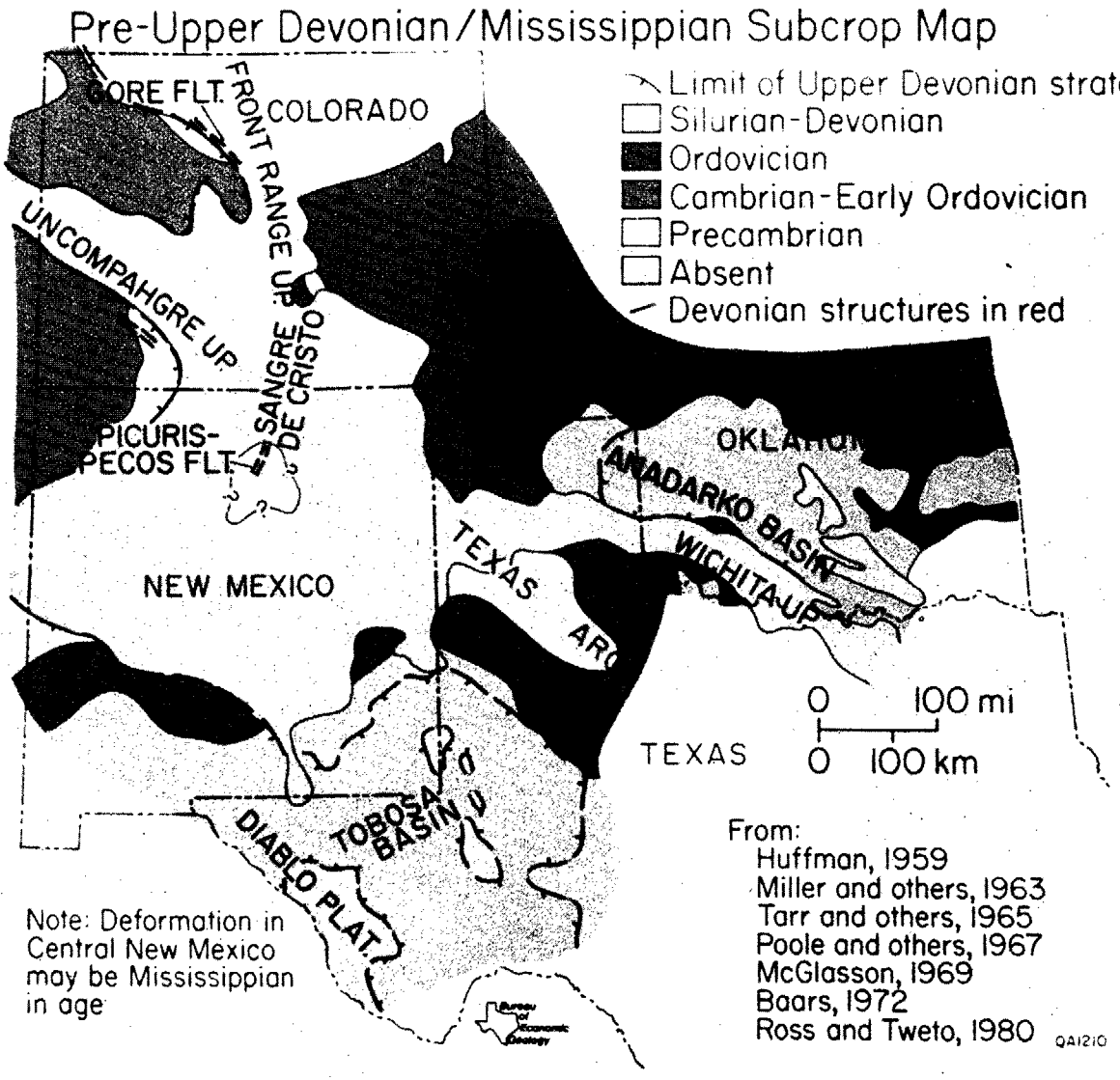

N
OKLAHOMA
TEXAS
Canadian R
L.
M.
Amarillo
Triassic
Wichita
Red R
OKLAHOMA
NEW MEXICO
TEXAS
Ogallala
M.
Permian
L.
TEXAS
0
50 mi
0
80 km
BEG

CORRELATION CHART

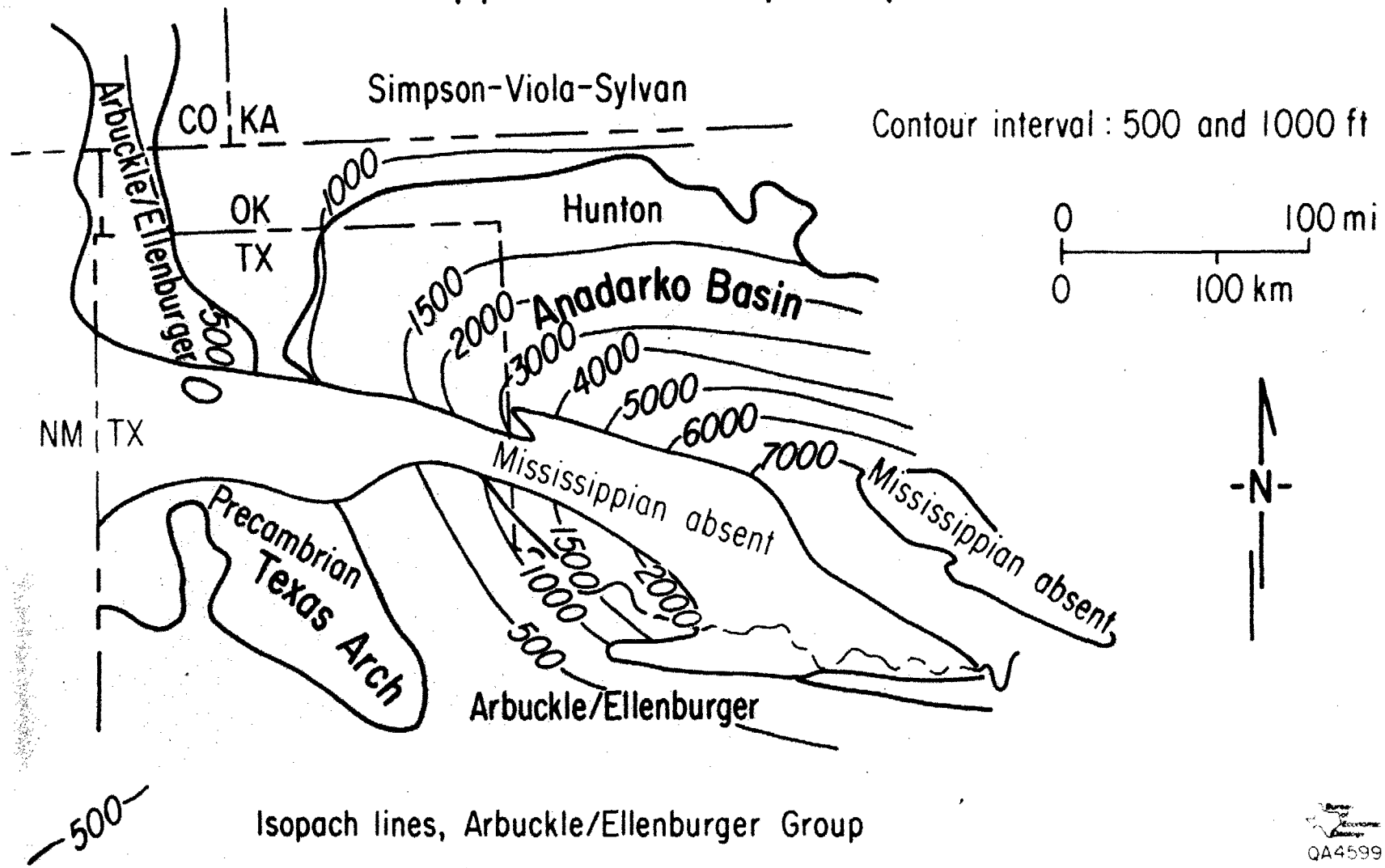



SW
NE
POTTER CO
MOORE CO
HUTCHINSON CO
Top Permian
Ogallala
Dockum
Canadian R.
Canadian R.
Blaine
Red Cave
Excell Dome
Wolfcamp
Basement
4000
3000
2000
1000
0
-1000
0 5mi
0 8km
MOORE
HUTCHINSON
POTTER
CARSON
QA 3730
BEG


Upper Cambrian-Lower Ordovician
Isopach Map
Absent
Early Ordovician structures in red
Contours in ft X 100
Contour intervals 100, 500,
1000 ft
COLORADO
FRONT RANGE UPLIFT
UNCOMPAHGRE UPLIFT
APISHAPA UPLIFT
NEW MEXICO
ANADARKO BASIN
OK.
TEXAS
PEDREGOSA BASIN
TOBOSA BASIN
DIABLO UPLIFT
0 100 mi
0 100 km
From:
Huffman, 1959
Hill, 1971
Greenwood and others, 1977
Ross and Tweto, 1980
QA1215


Pre-Upper Devonian/Mississippian Subcrop Map
Limit of Upper Devonian strata
Silurian-Devonian
Ordovician
Cambrian-Early Ordovician
Precambrian
Absent
Devonian structures in red
ORE FLT.
FRONT RANGE UP.
COLORADO
UNCOMPAHGRE UP.
SANGRE DE CRISTO
PICURIS-
PECOS FLT.
NEW MEXICO
AMADARKO BASIN
WICHITA-UP
TEXAS
ARC
0 100 mi
TEXAS
0 100 km
TOBOSA BASIN
DIABLO PLAT.
Note: Deformation in Central New Mexico may be Mississippian in age
From:
Huffman, 1959
Miller and others, 1963
Tarr and others, 1965
Poole and others, 1967
McGlasson, 1969
Baars, 1972
Ross and Tweto, 1980
QA1210

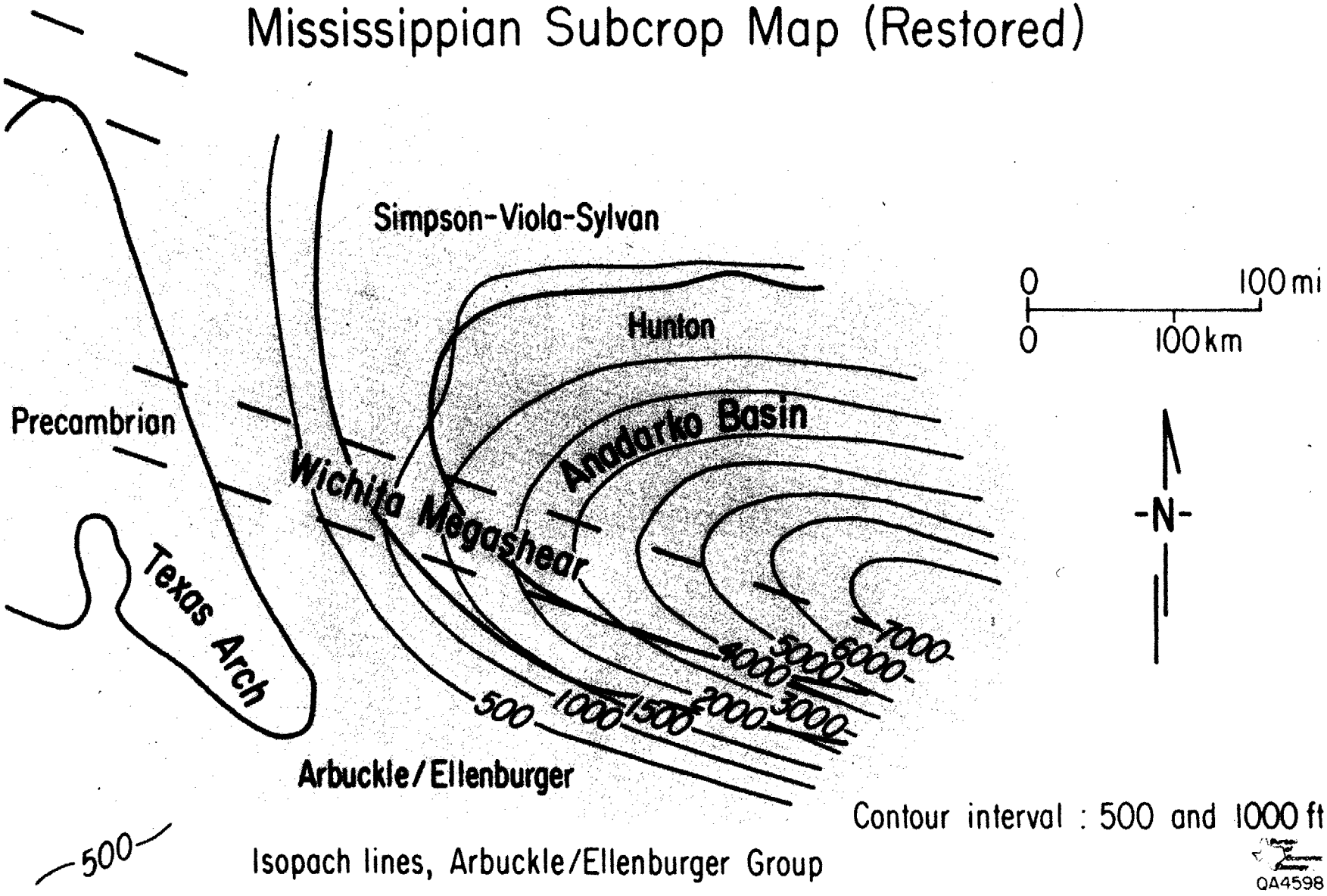
Mississippian Subcrop Map (Present)



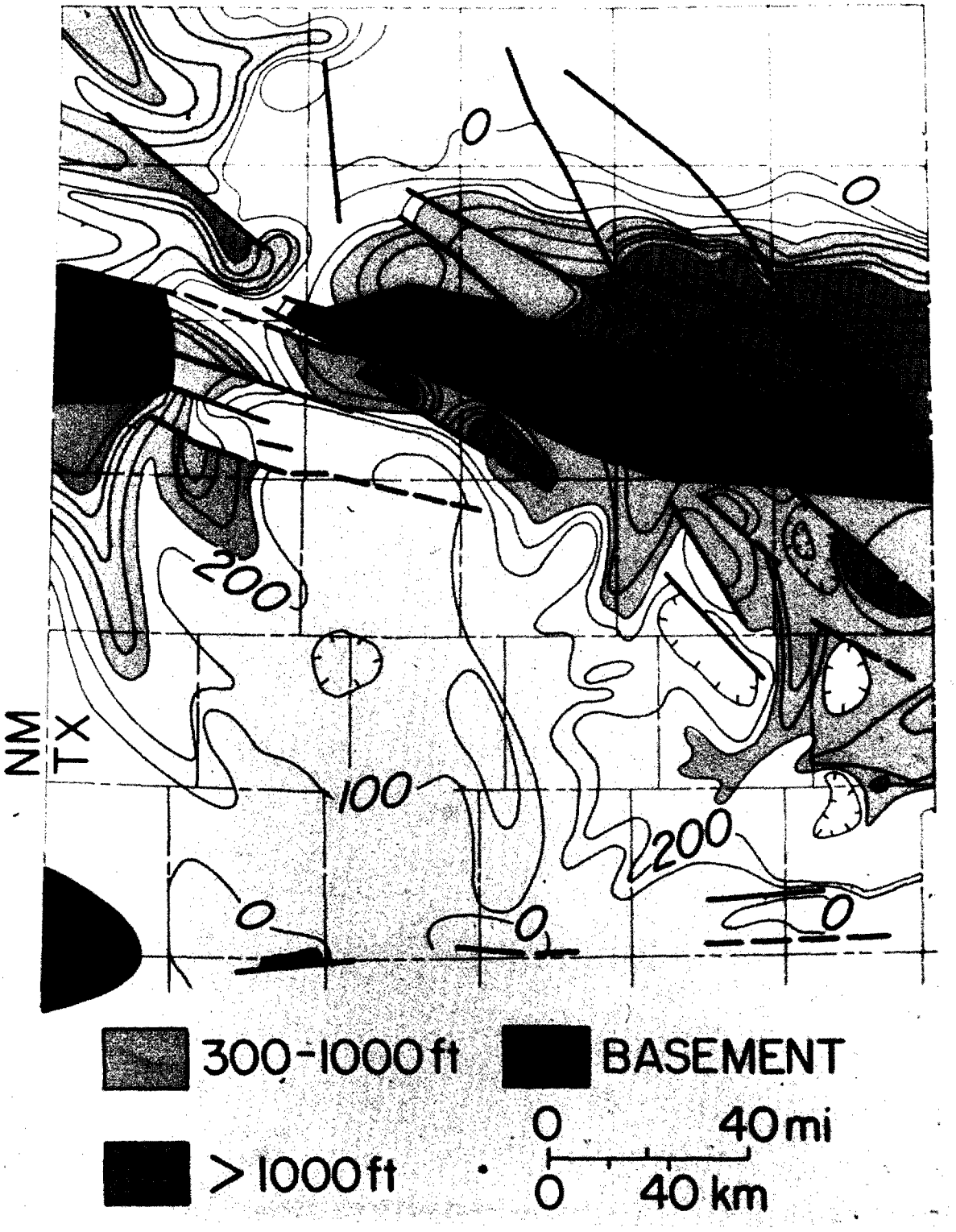
Isopach lines, Arbuckle/Ellenburger Group

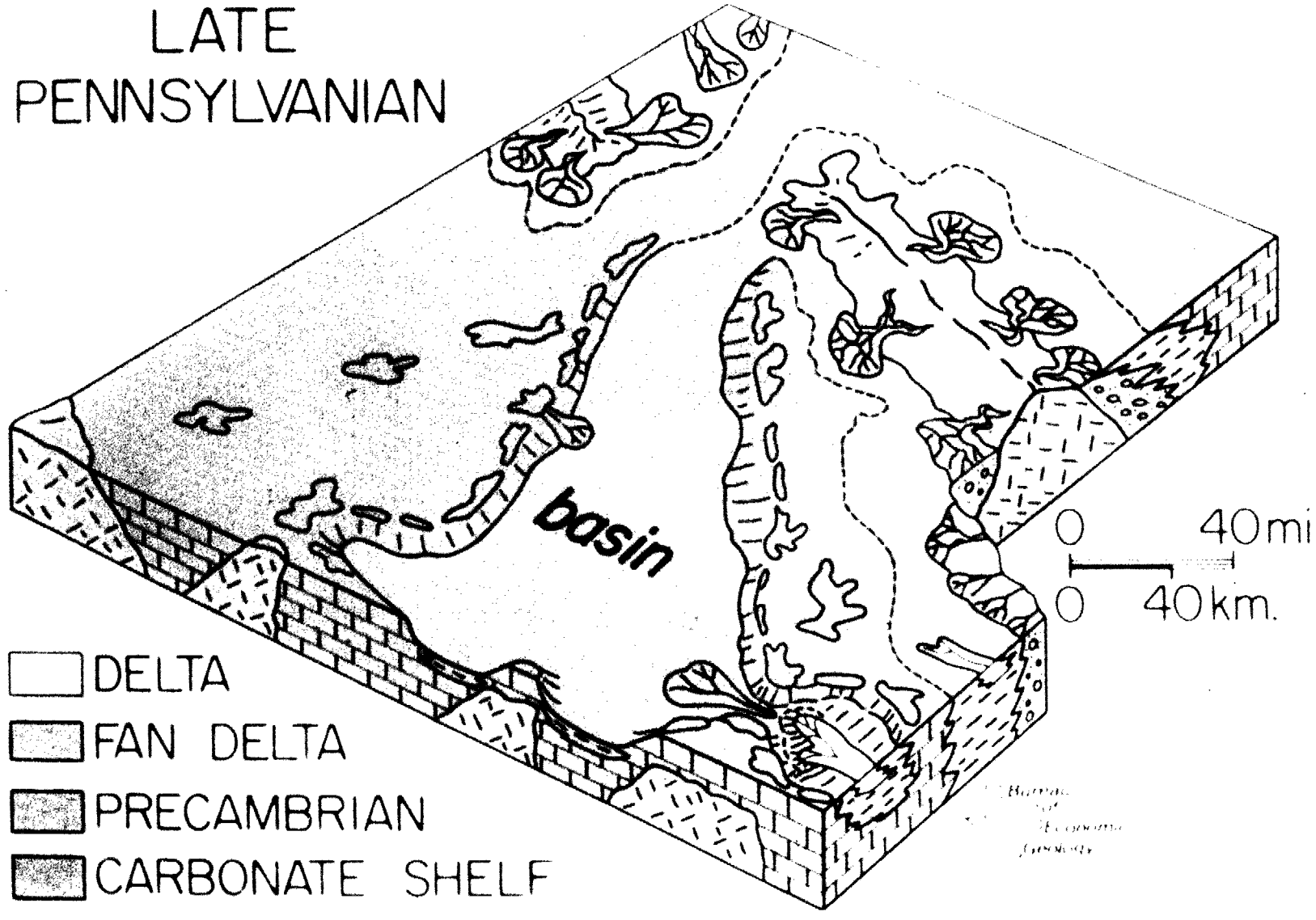
QA4599

Mississippian Subcrop Map (Restored)



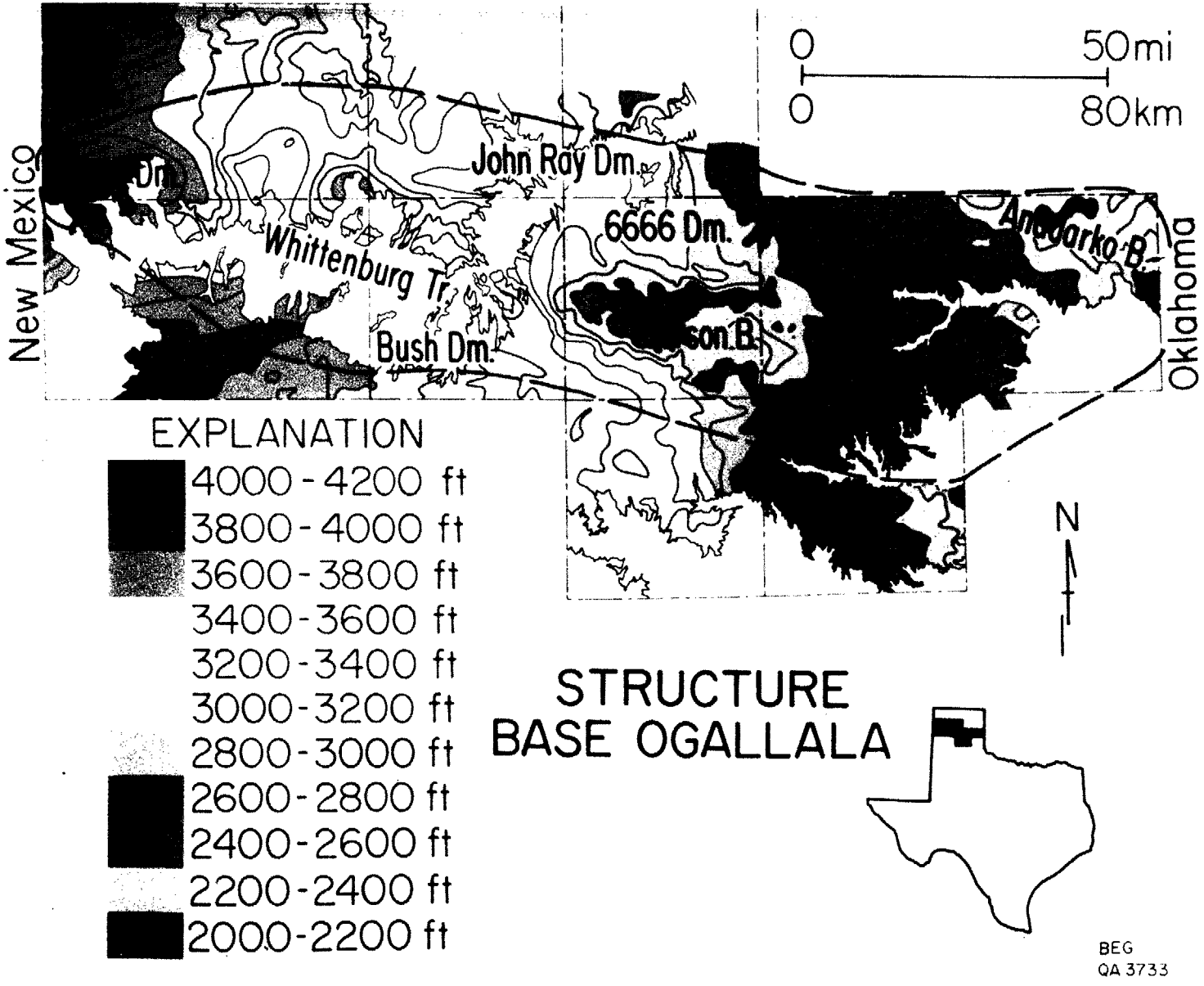
NET GRANITE WASH



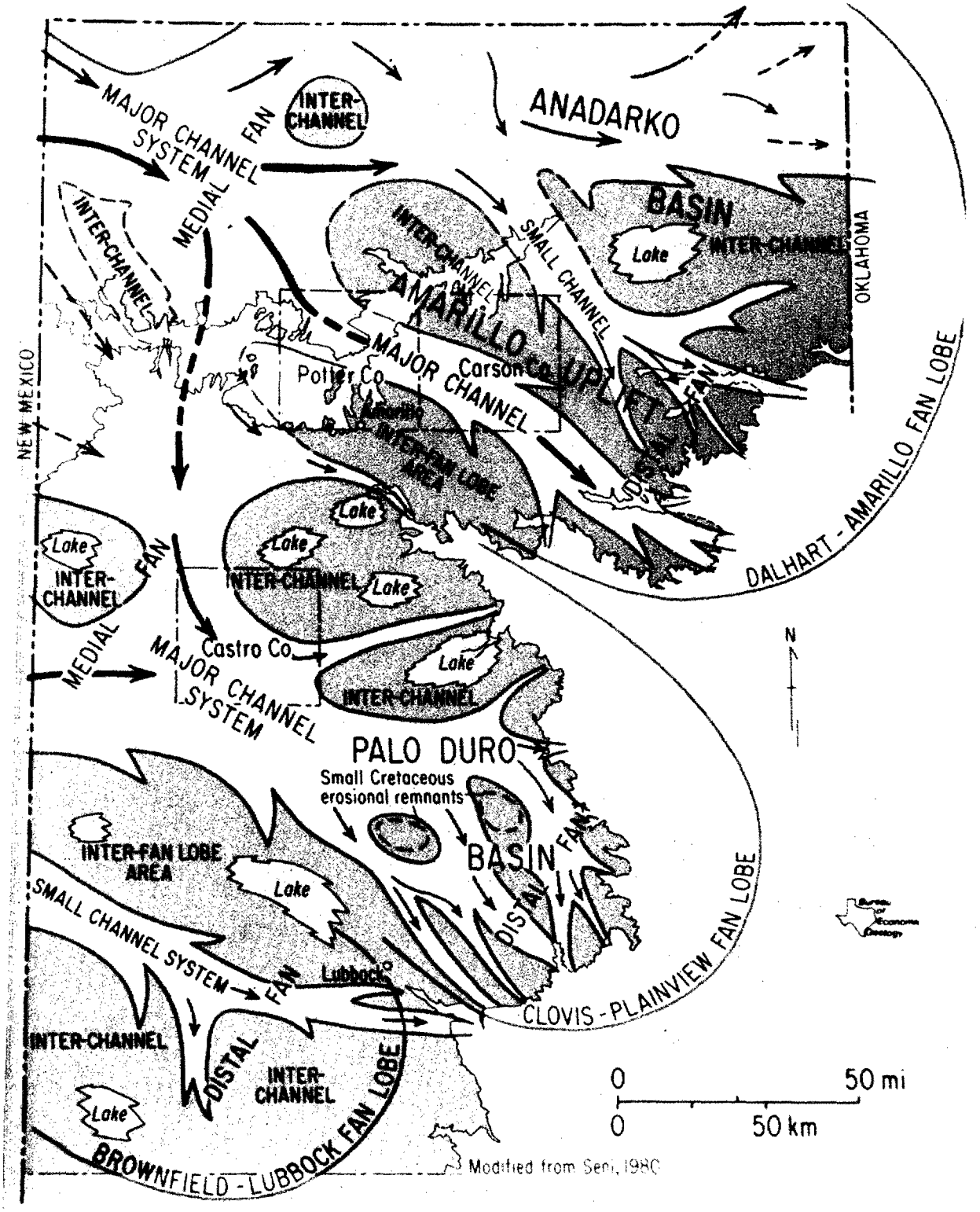

LATE
PENNSYLVANIAN
basin
0 40mi
0 40km.
DELTA
FAN DELTA
PRECAMBRIAN
CARBONATE SHELF

ISOPACH
PERMIAN post Wolfcamp

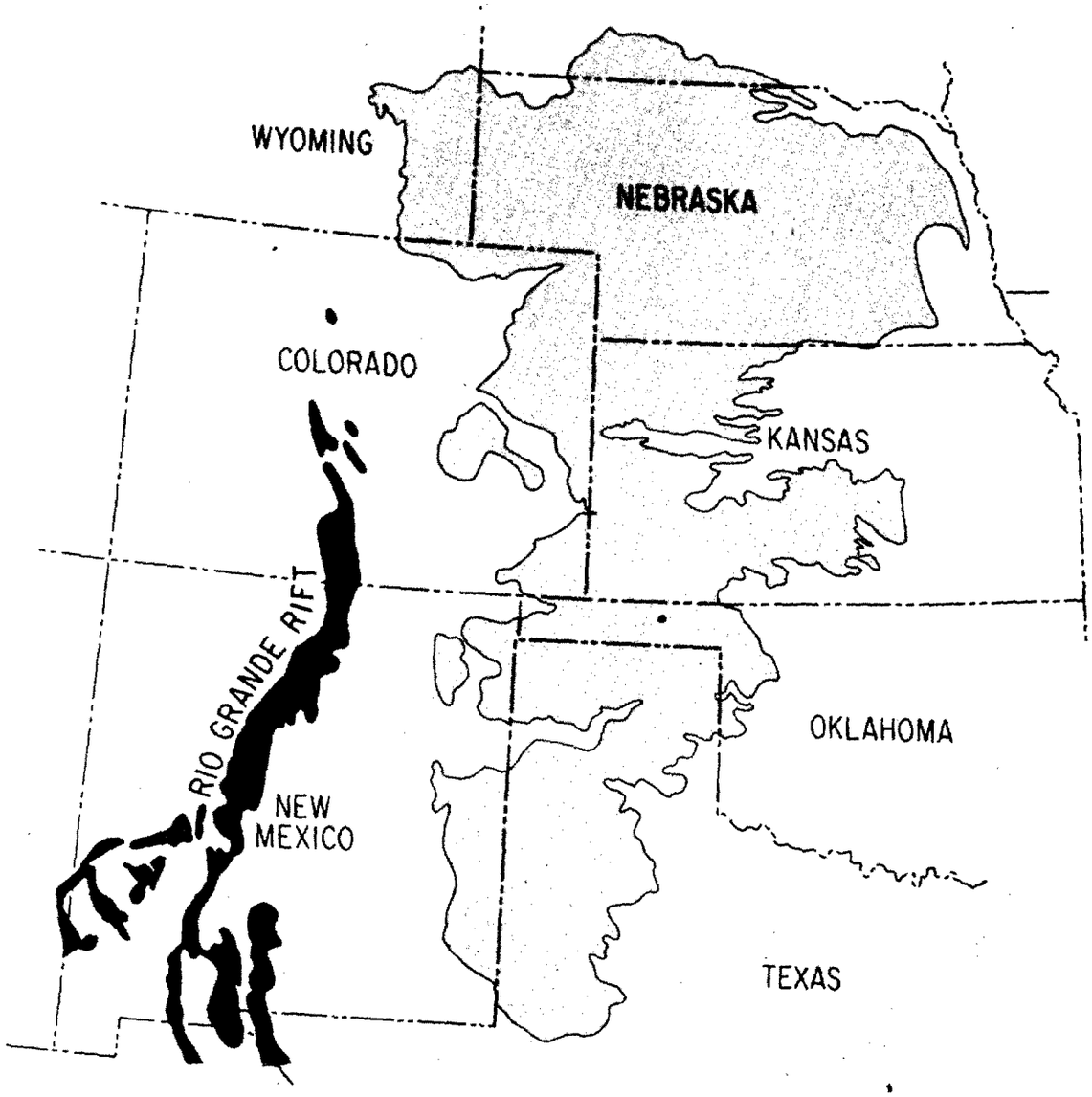
BEG
QA-3223


0
50mi
0
80km
New Mexico
Oklahoma
John Ray Dm.
6666 Dm.
Whittenburg Tr.
Bush Dm.
Anadarko B.
N
EXPLANATION
4000 - 4200 ft
3800 - 4000 ft
3600 - 3800 ft
3400 - 3600 ft
3200 - 3400 ft
3000 - 3200 ft
2800 - 3000 ft
2600 - 2800 ft
2400 - 2600 ft
2200 - 2400 ft
2000 - 2200 ft
STRUCTURE
BASE OGALLALA
BEG
QA 3733

DEPOSITIONAL PATTERNS OF OGALLALA FM.



DISTRIBUTION OF NEOGENE SEDIMENTS



Ogallala Fm.

Santa Fe and related fms.

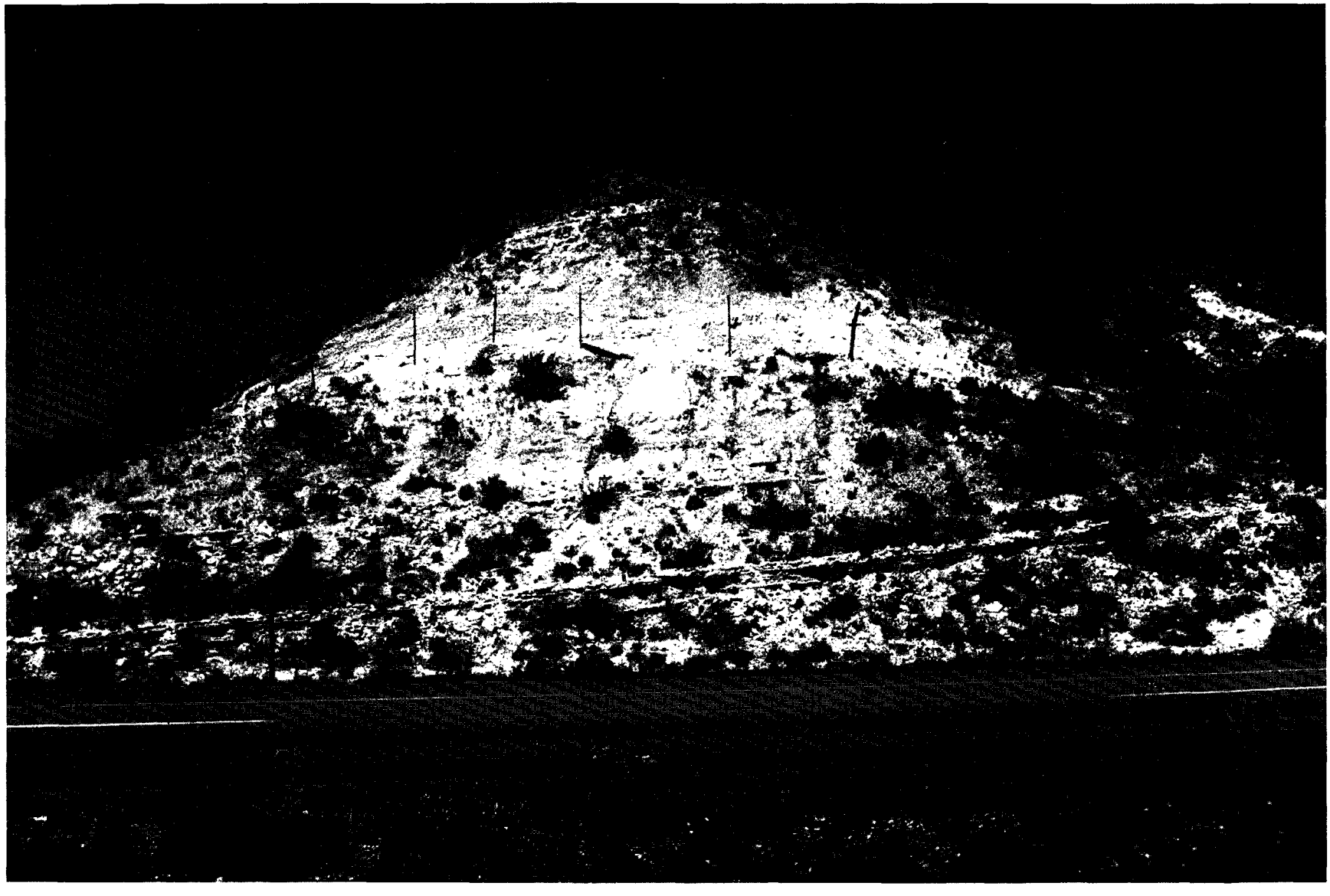
0 200 mi

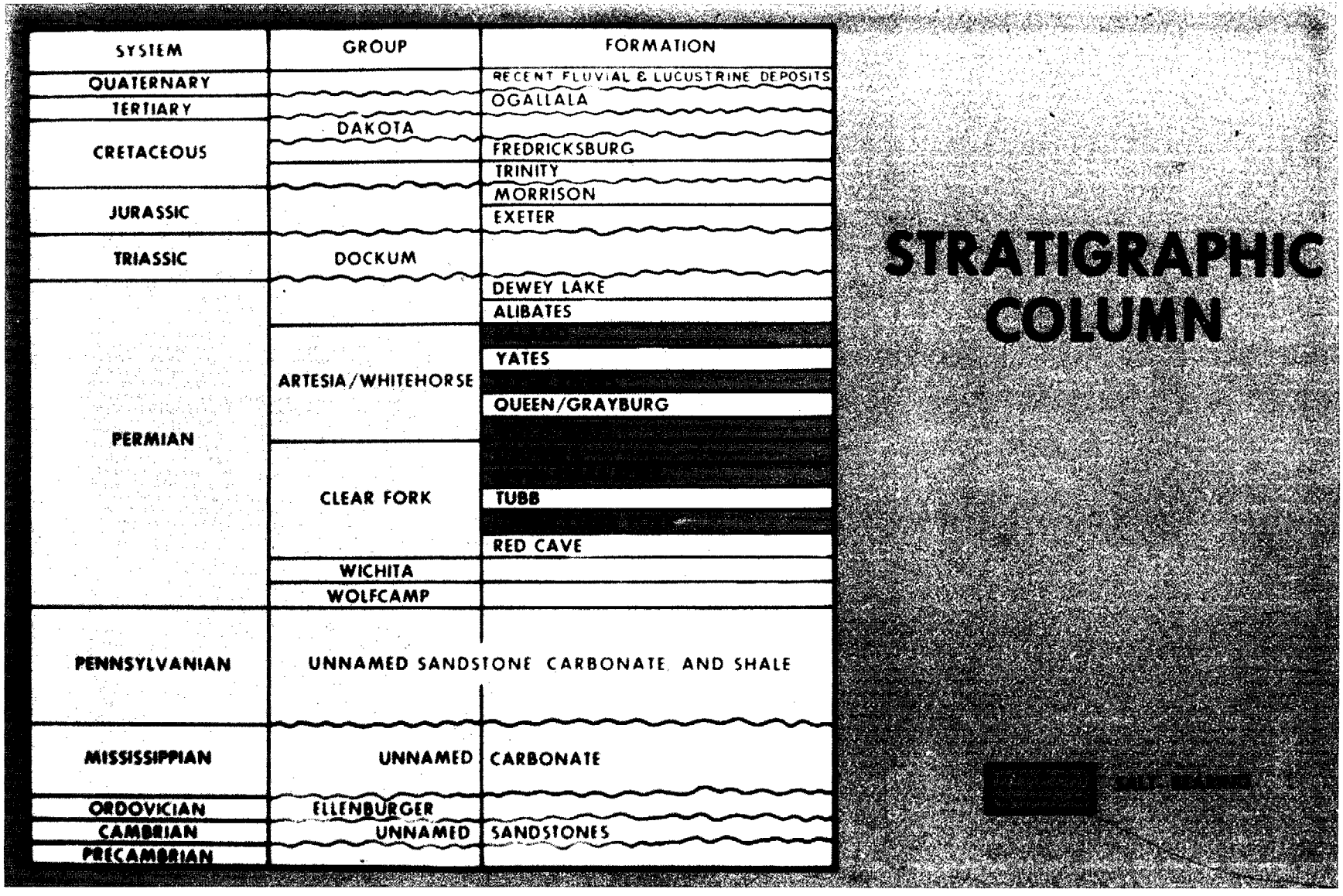
0 200 km

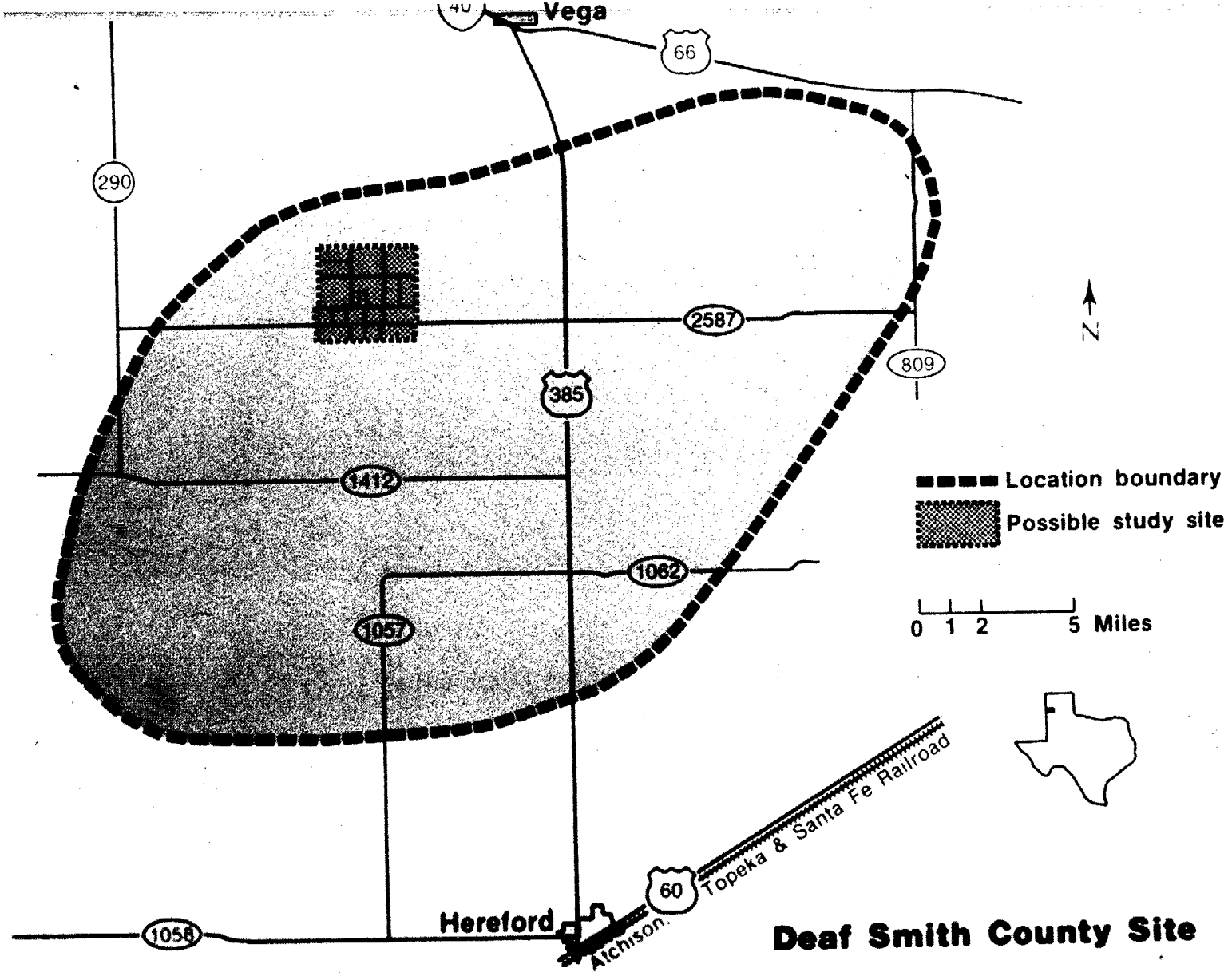
Sources

Dane and Bachman, 1965
Knepper, 1976
Tedford, 1981
Weeks and Gutentag, 1981

QA2038

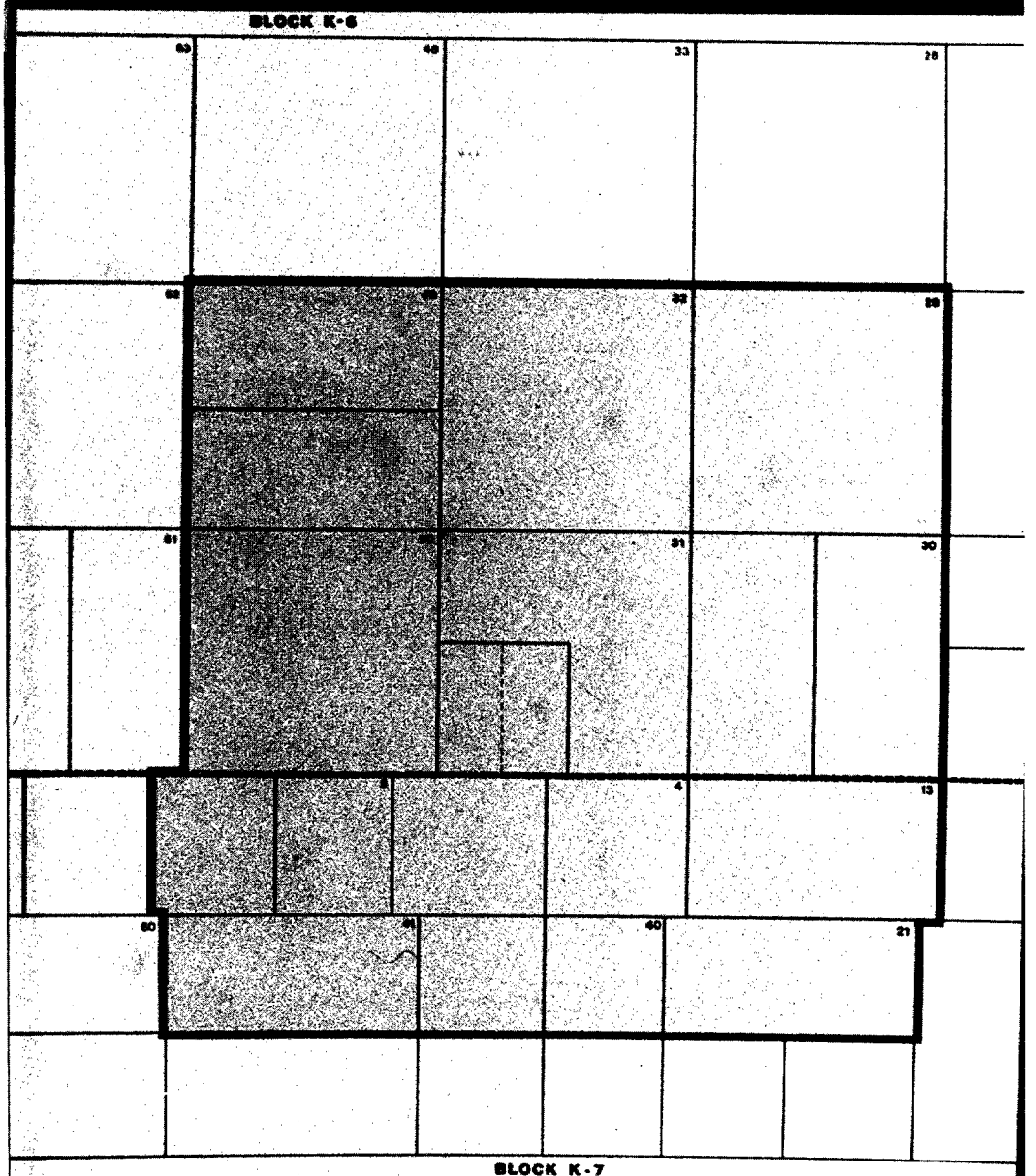



SYSTEM
GROUP
FORMATION
QUATERNARY
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
PENNSYLVANIAN
MISSISSIPPIAN
ORDOVICIAN
CAMBRIAN
PRECAMBRIAN
DAKOTA
DOCKUM
ARTESIA/WHITEHORSE
CLEAR FORK
WICHITA
WOLFCAMP
UNNAMED
ELLENBURGER
UNNAMED
RECENT FLUVIAL & LUCUSTRINE DEPOSITS
OGALLALA
FREDRICKSBURG
TRINITY
MORRISON
EXETER
DEWEY LAKE
ALIBATES
YATES
QUEEN/GRAYBURG
TUBB
RED CAVE
UNNAMED SANDSTONE CARBONATE AND SHALE
CARBONATE
SANDSTONES
STRATIGRAPHIC COLUMN


Vega
66
290
2587
809
385
1412
1062
1057
1058
Hereford
60
Atchison, Topeka & Santa Fe Railroad
N
Location boundary
Possible study site
0 1 2 5 Miles
Deaf Smith County Site

Possible 9-Square-Mile Study Site Deaf Smith County, Texas

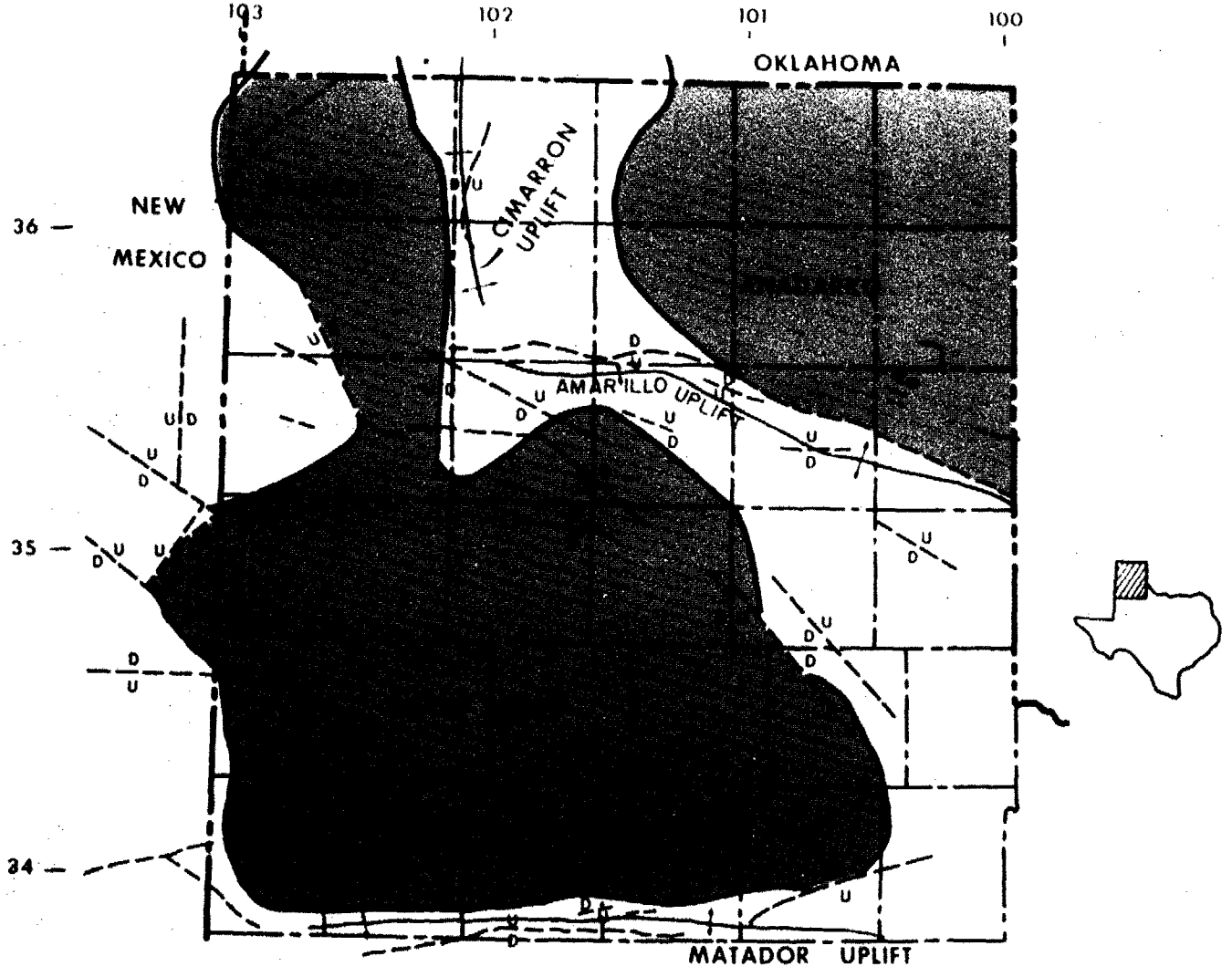
G.B.&C.N.G. RR

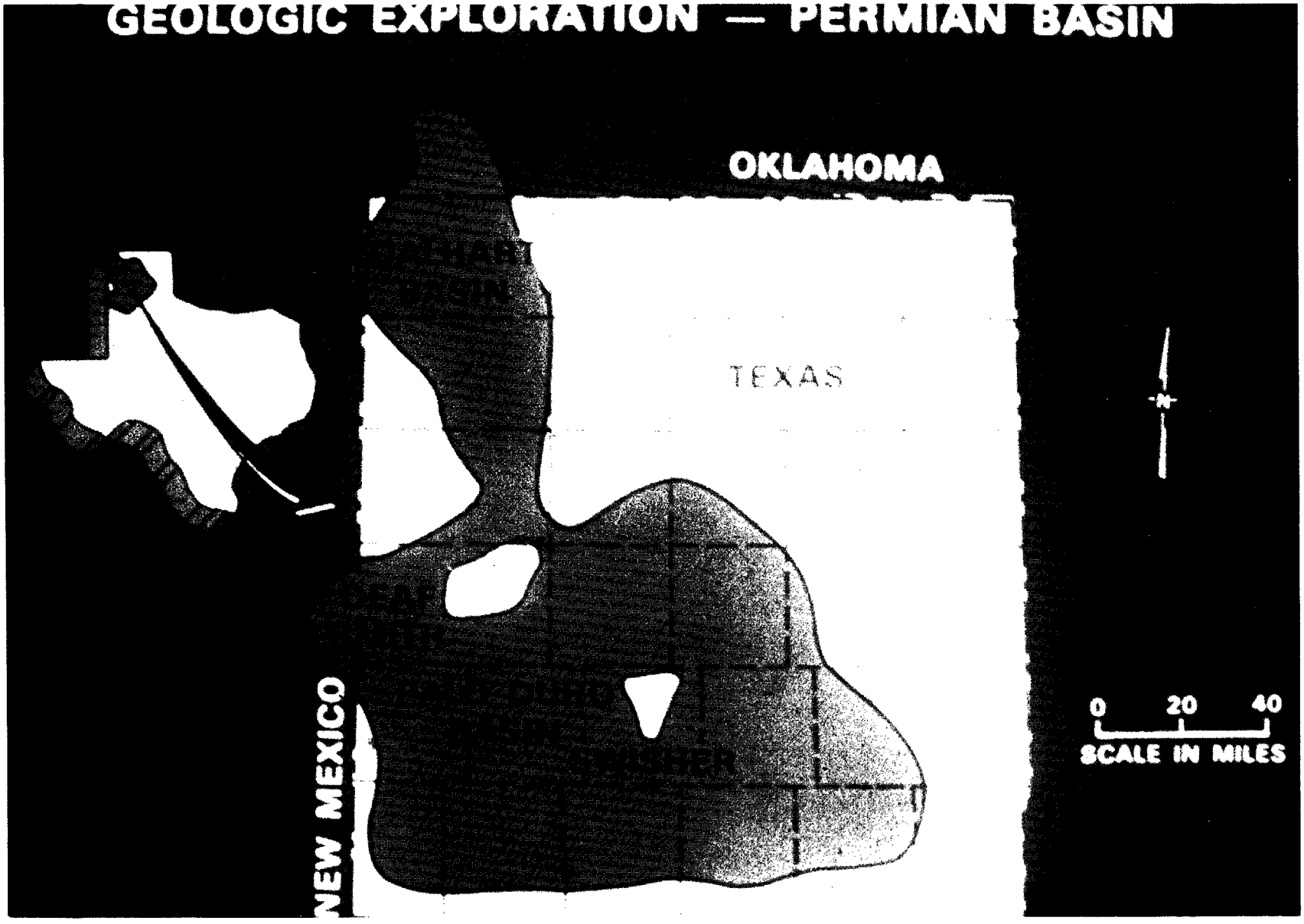


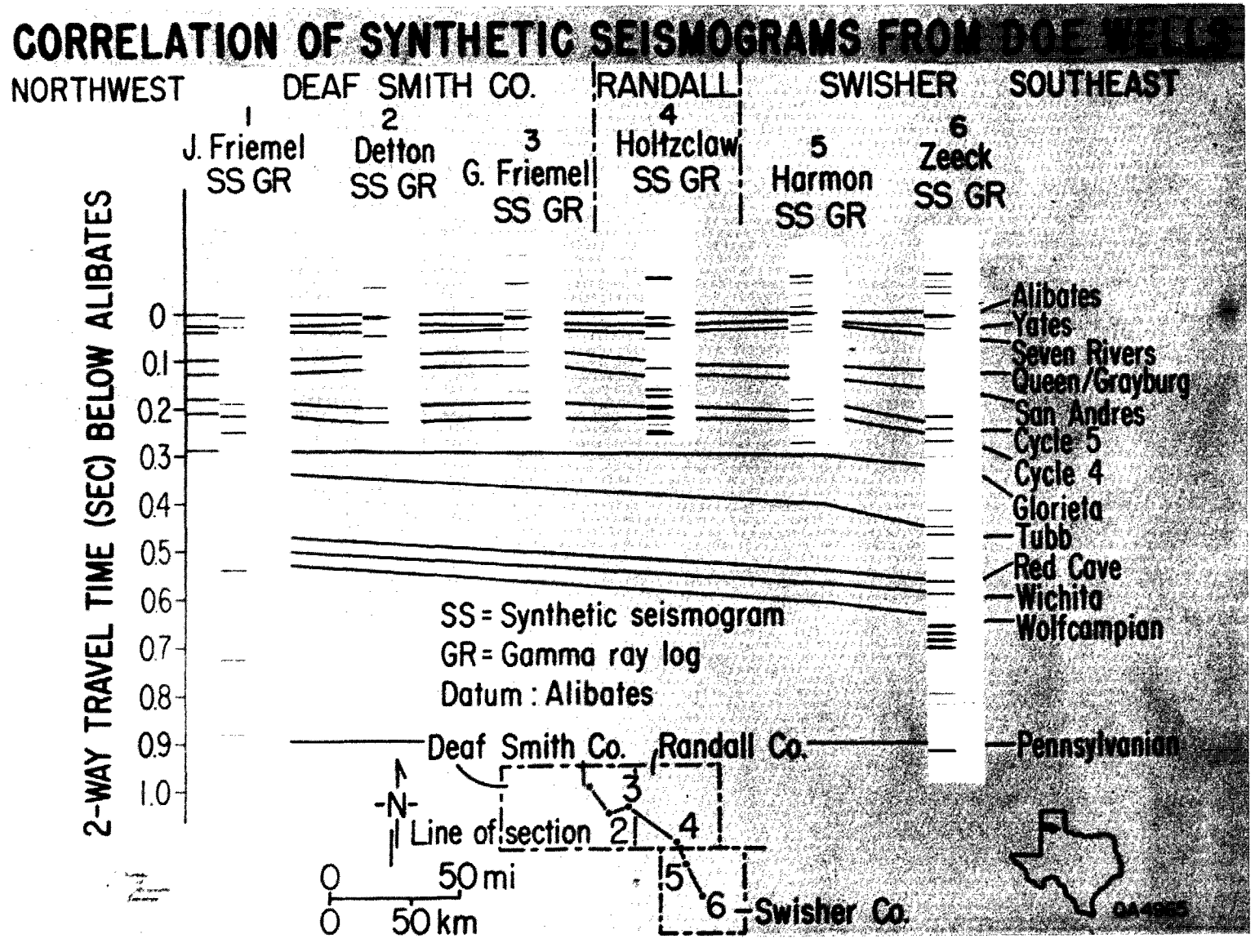
Possible study site boundary

Block boundary

TECTONIC MAP

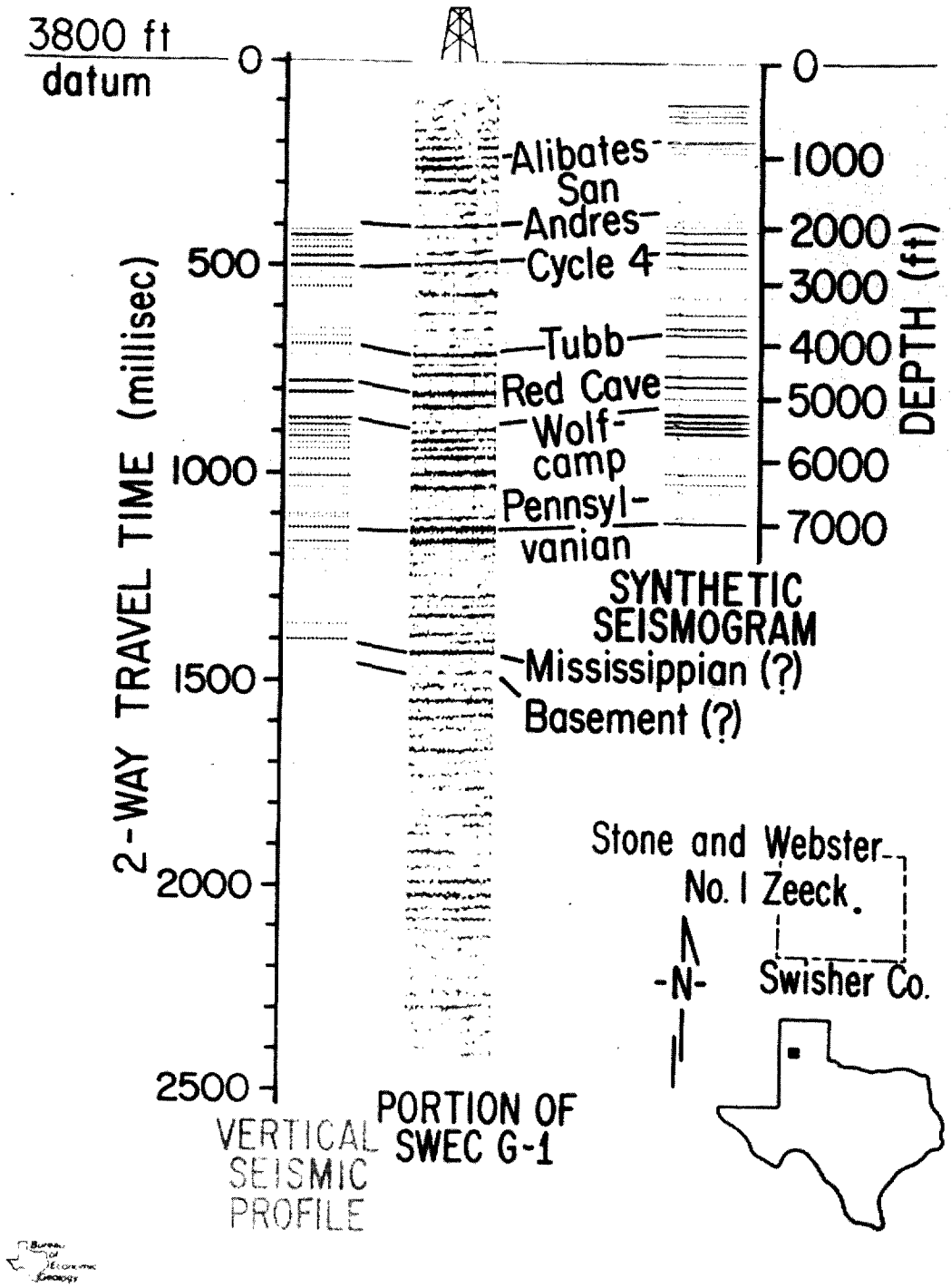



GEOLOGIC EXPLORATION — PERMIAN BASIN
OKLAHOMA
TEXAS
NEW MEXICO
0 20 40
SCALE IN MILES

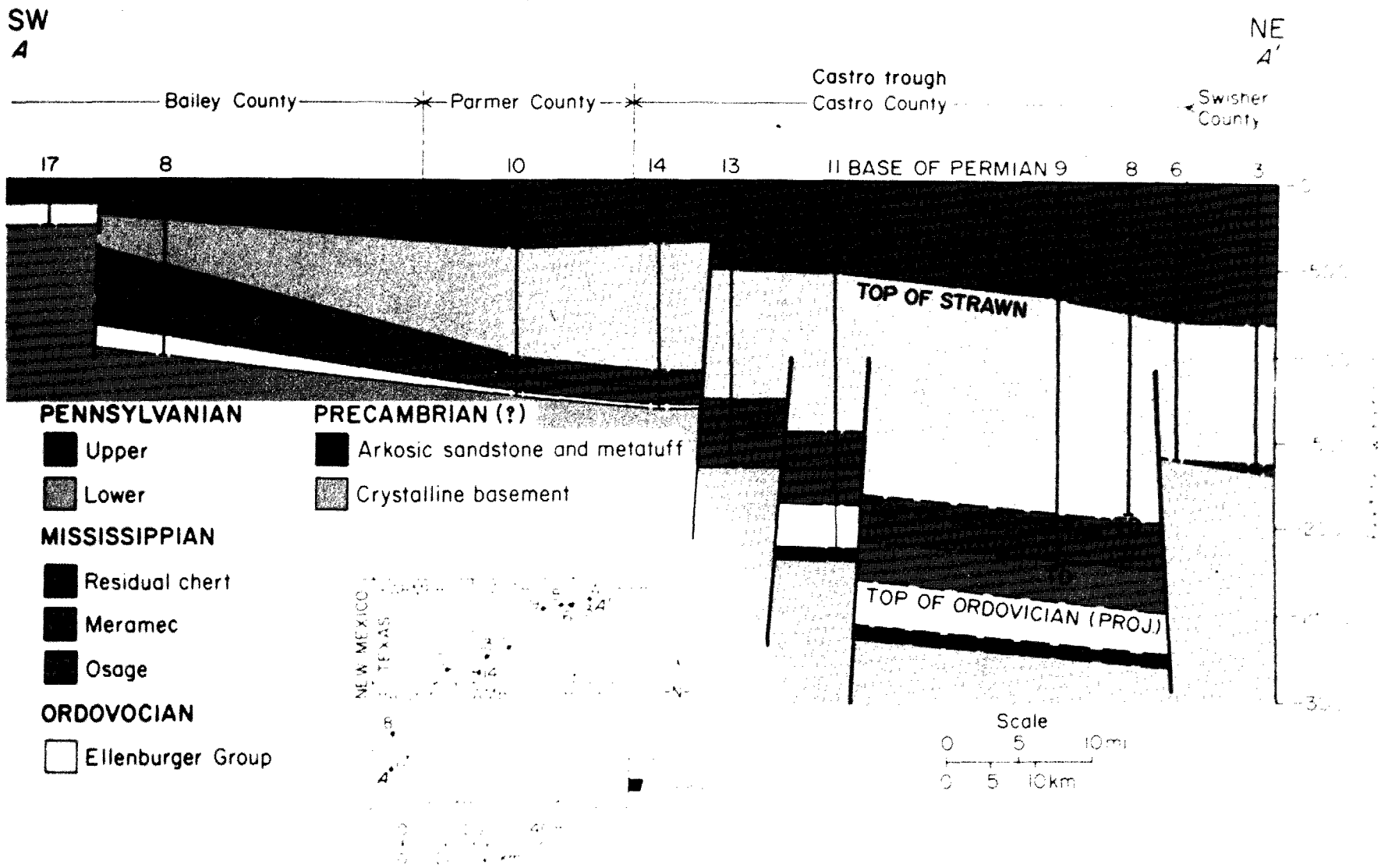

CORRELATION OF SYNTHETIC SEISMOGRAMS FROM DOE WELLS
NORTHWEST
DEAF SMITH CO.
RANDALL
SWISHER
SOUTHEAST
1
J. Friemel
SS GR
2
Detton
SS GR
3
G. Friemel
SS GR
4
Holtzclaw
SS GR
5
Harmon
SS GR
6
Zeeck
SS GR
2-WAY TRAVEL TIME (SEC) BELOW ALIBATES
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Alibates
Yates
Seven Rivers
Queen/Grayburg
San Andres
Cycle 5
Cycle 4
Glorieta
Tubb
Red Cave
Wichita
Wolfcampian
Pennsylvanian
SS = Synthetic seismogram
GR = Gamma ray log
Datum : Alibates
Deaf Smith Co.
Randall Co.
Swisher Co.
-N-
Line of section
0 50 mi
0 50 km

CORRELATION OF VSP, SYNTHETIC SEISMOGRAMS, & SEISMIC DATA

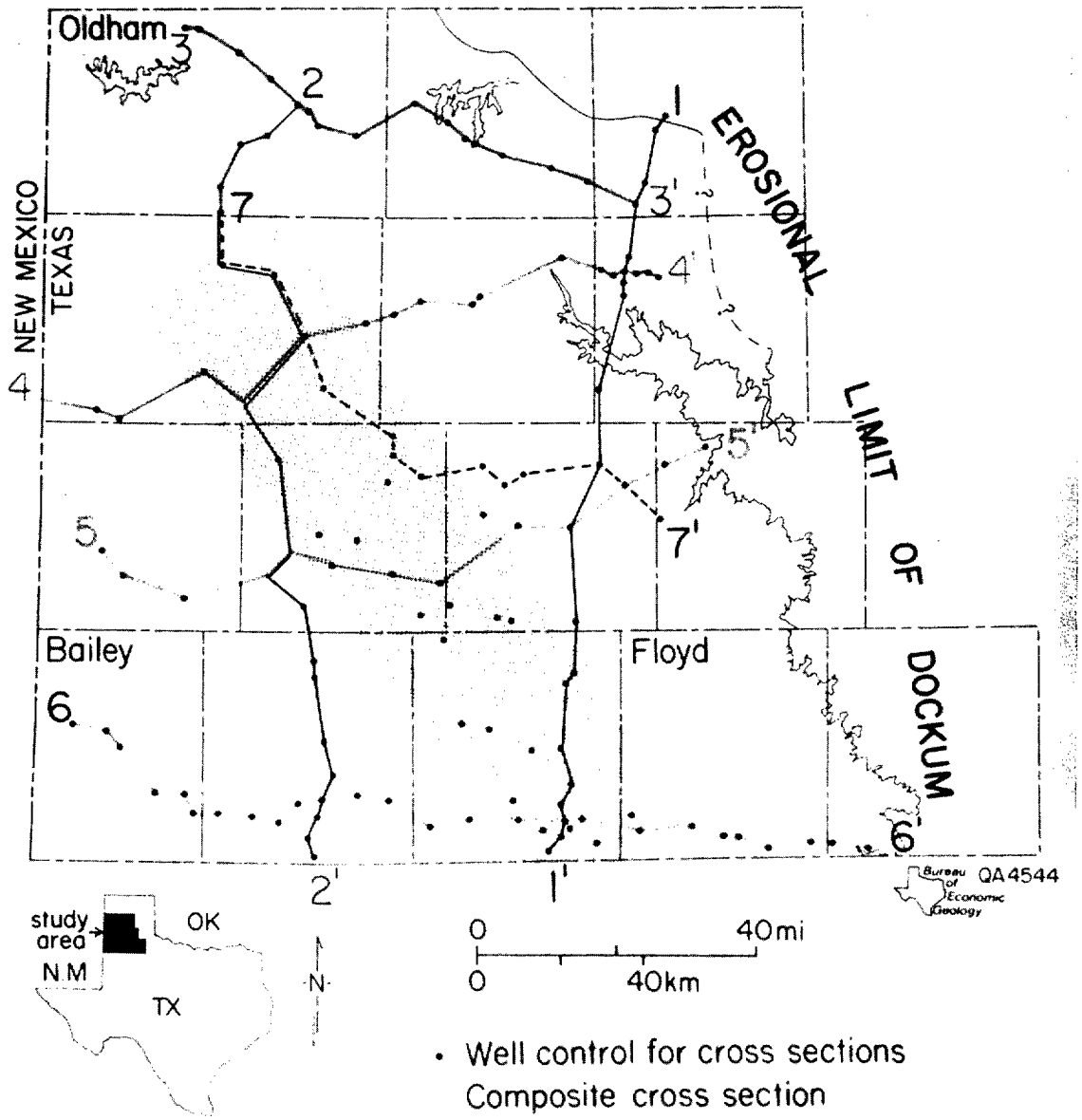
Stone and Webster
No. 1 Zeeck



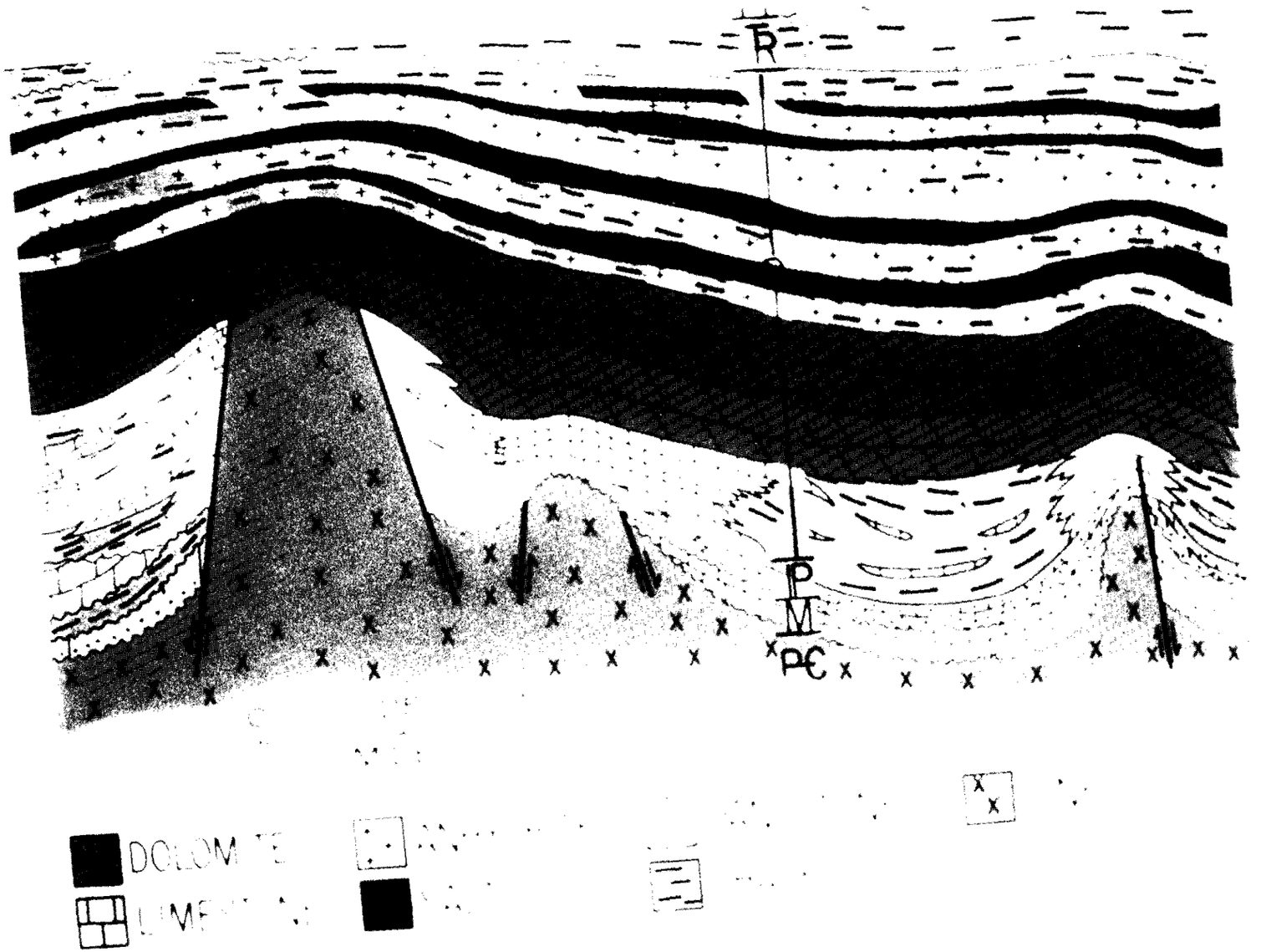
QA4966

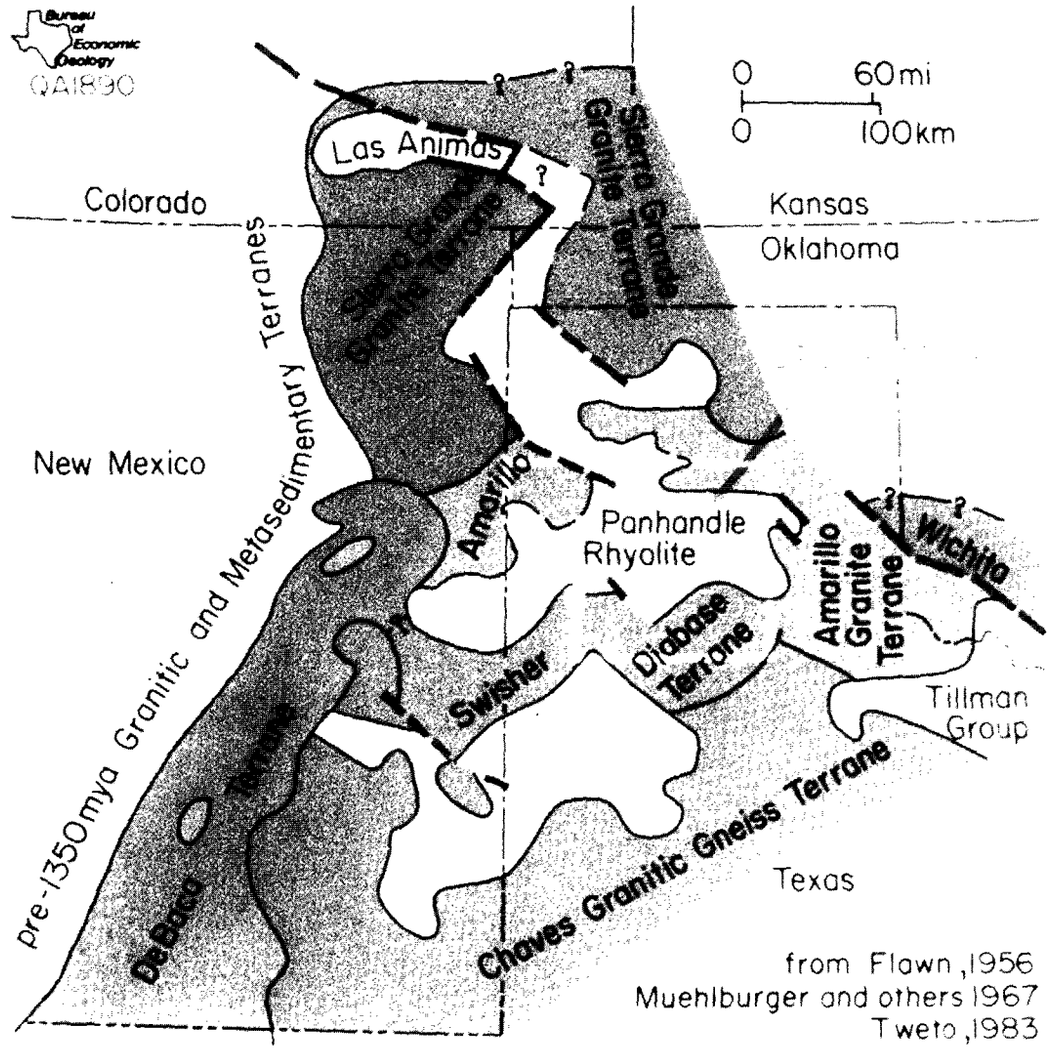

SW
A
NE
A'
Bailey County
Parmer County
Castro trough
Castro County
Swisher County
17
8
10
14
13
11 BASE OF PERMIAN 9
8
6
3
TOP OF STRAWN
TOP OF ORDOVICIAN (PROJ.)
PENNSYLVANIAN
Upper
Lower
MISSISSIPPIAN
Residual chert
Meramec
Osage
ORDOVOCIAN
Ellenburger Group
PRECAMBRIAN (?)
Arkosic sandstone and metatuff
Crystalline basement
NEW MEXICO
TEXAS
Scale
0 5 10 mi
0 5 10 km

INDEX MAP

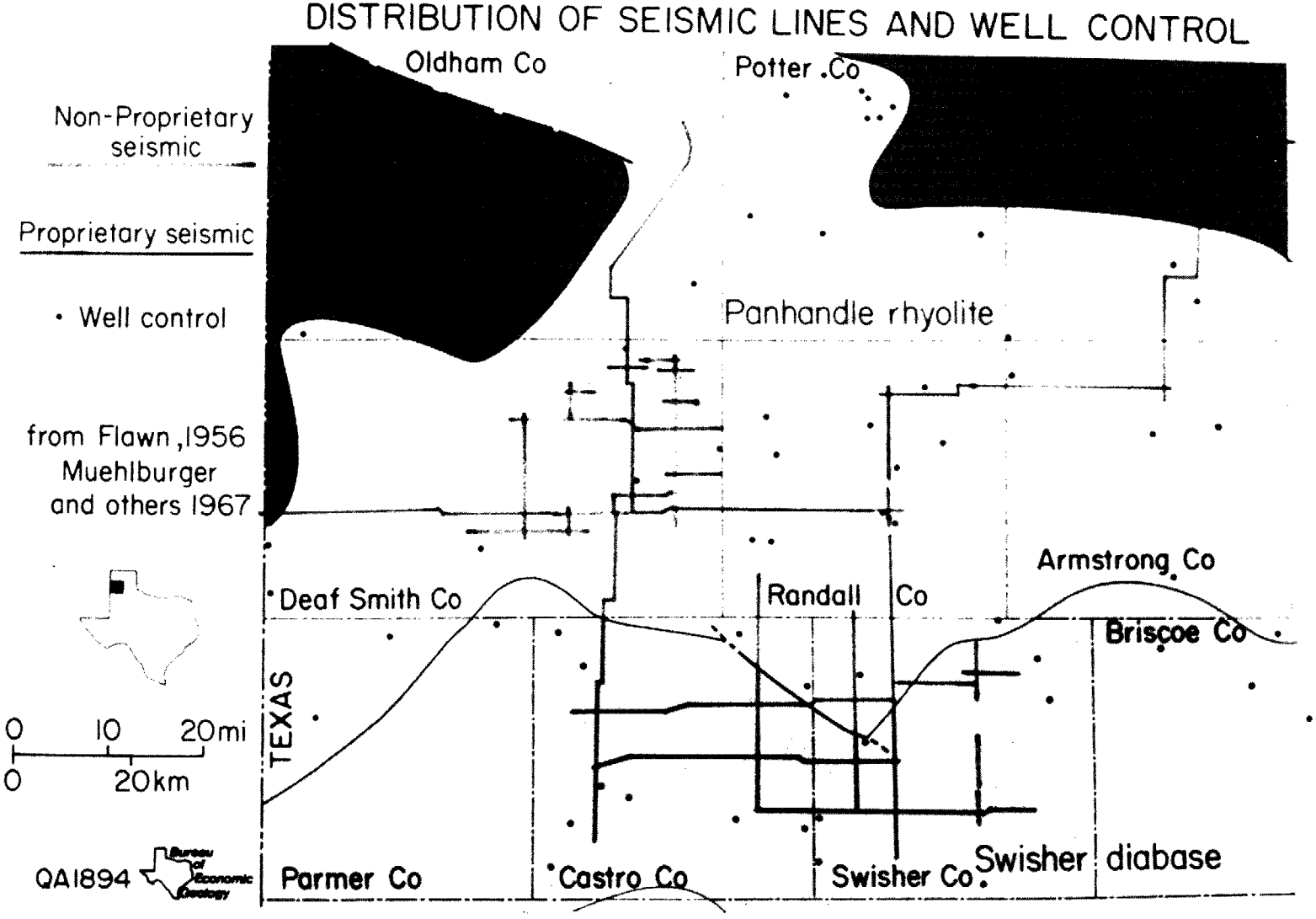


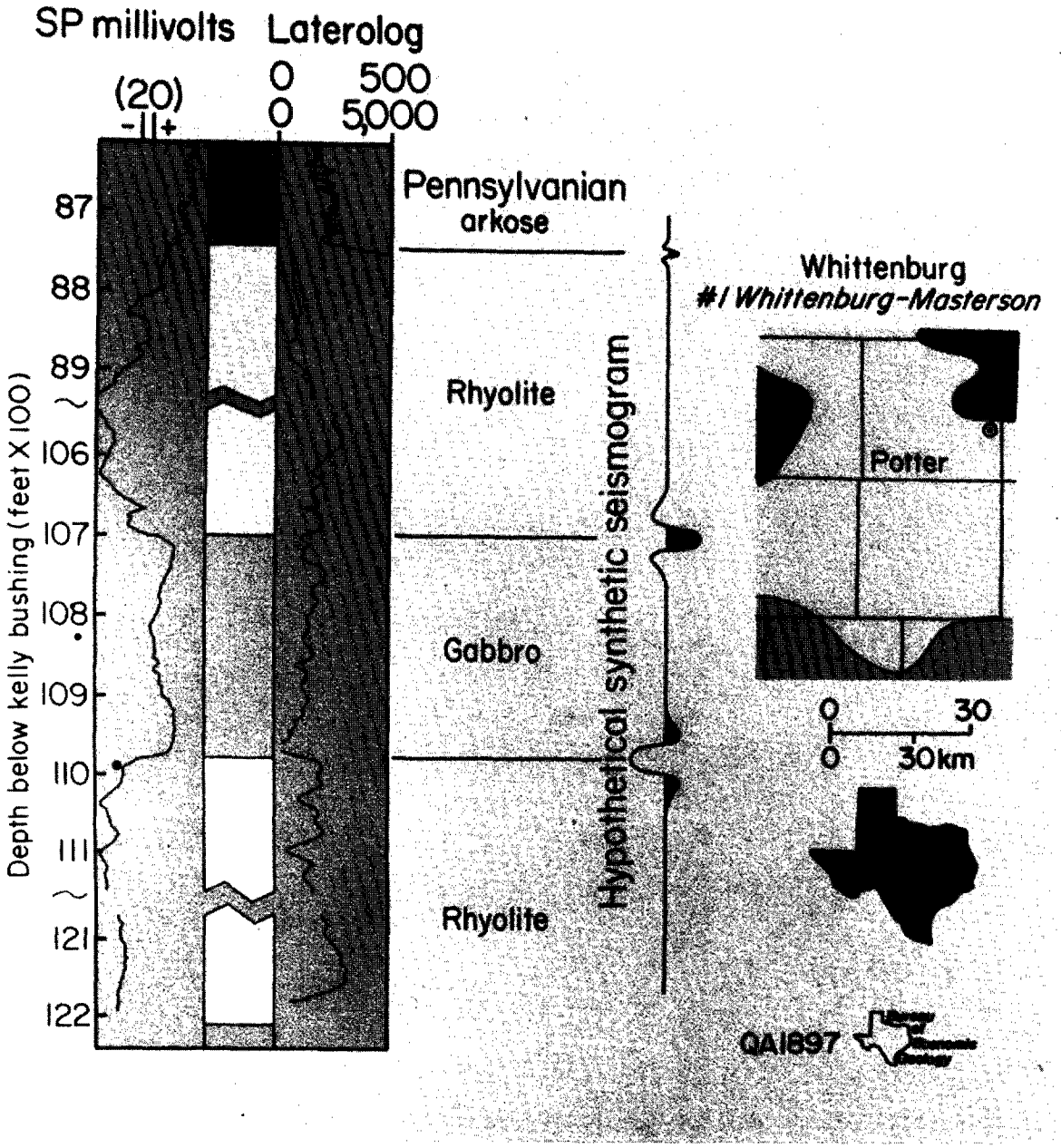
• Well control for cross sections
Composite cross section

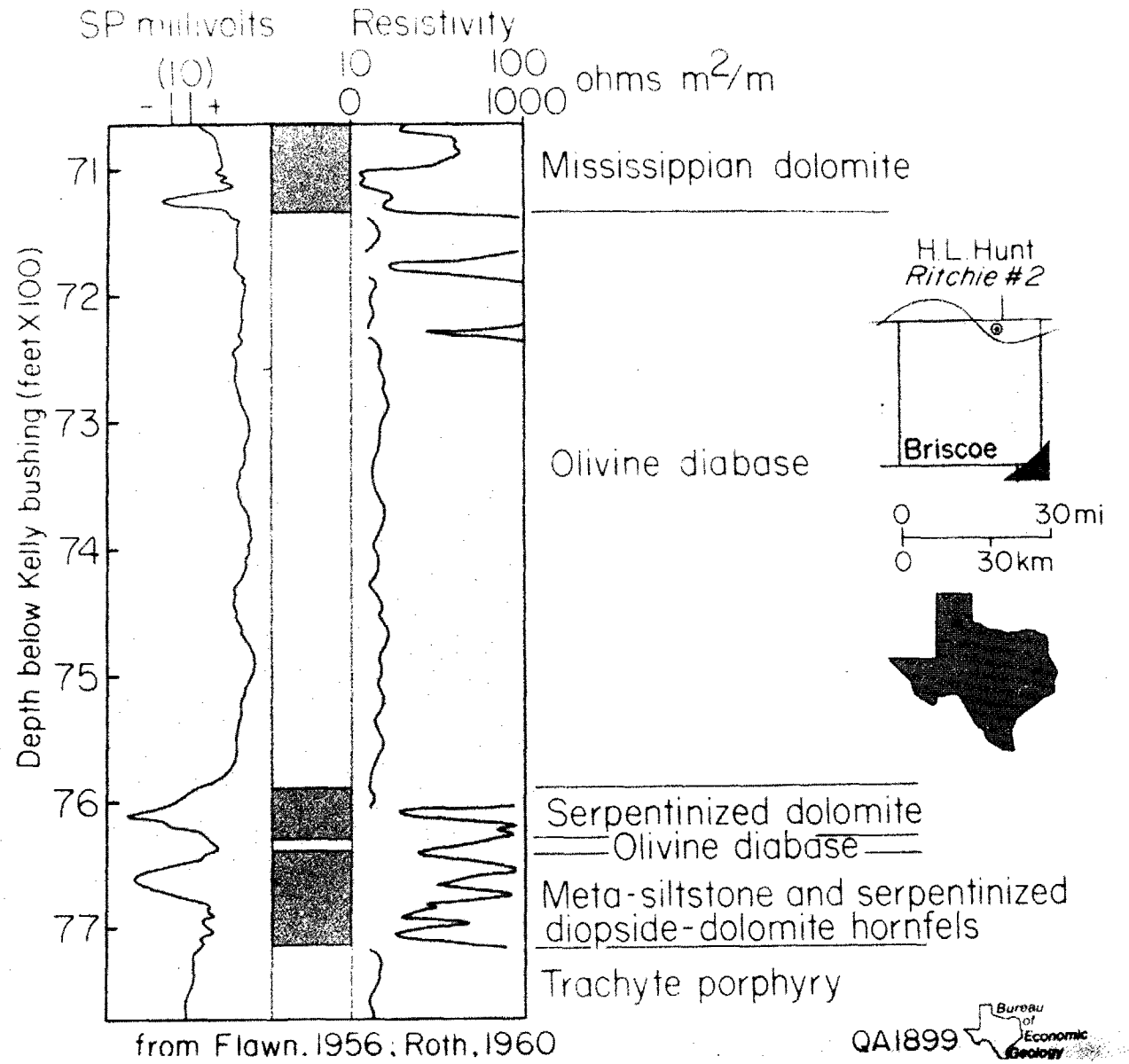

R
P
M
PC
DOLOMITE

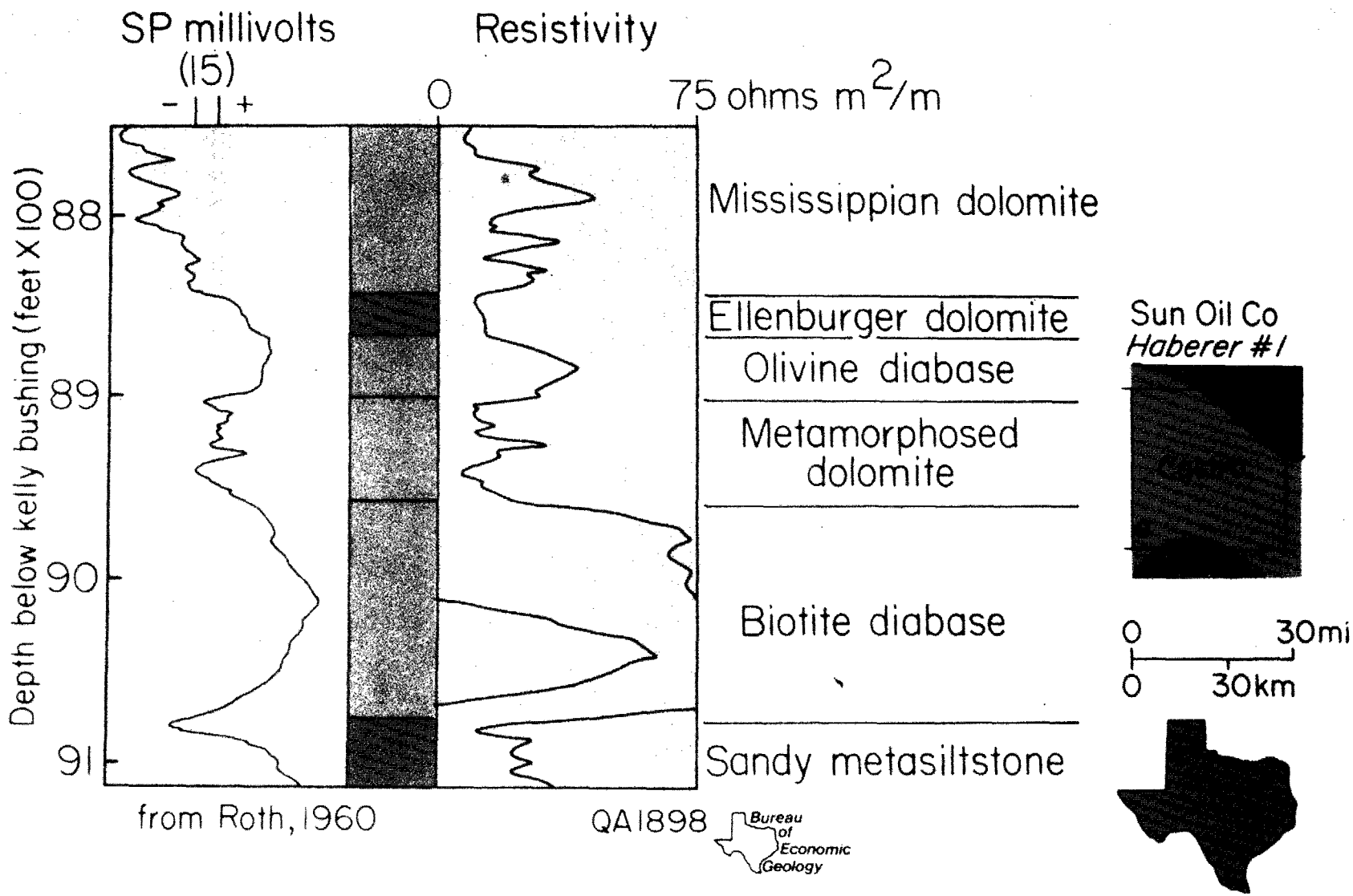


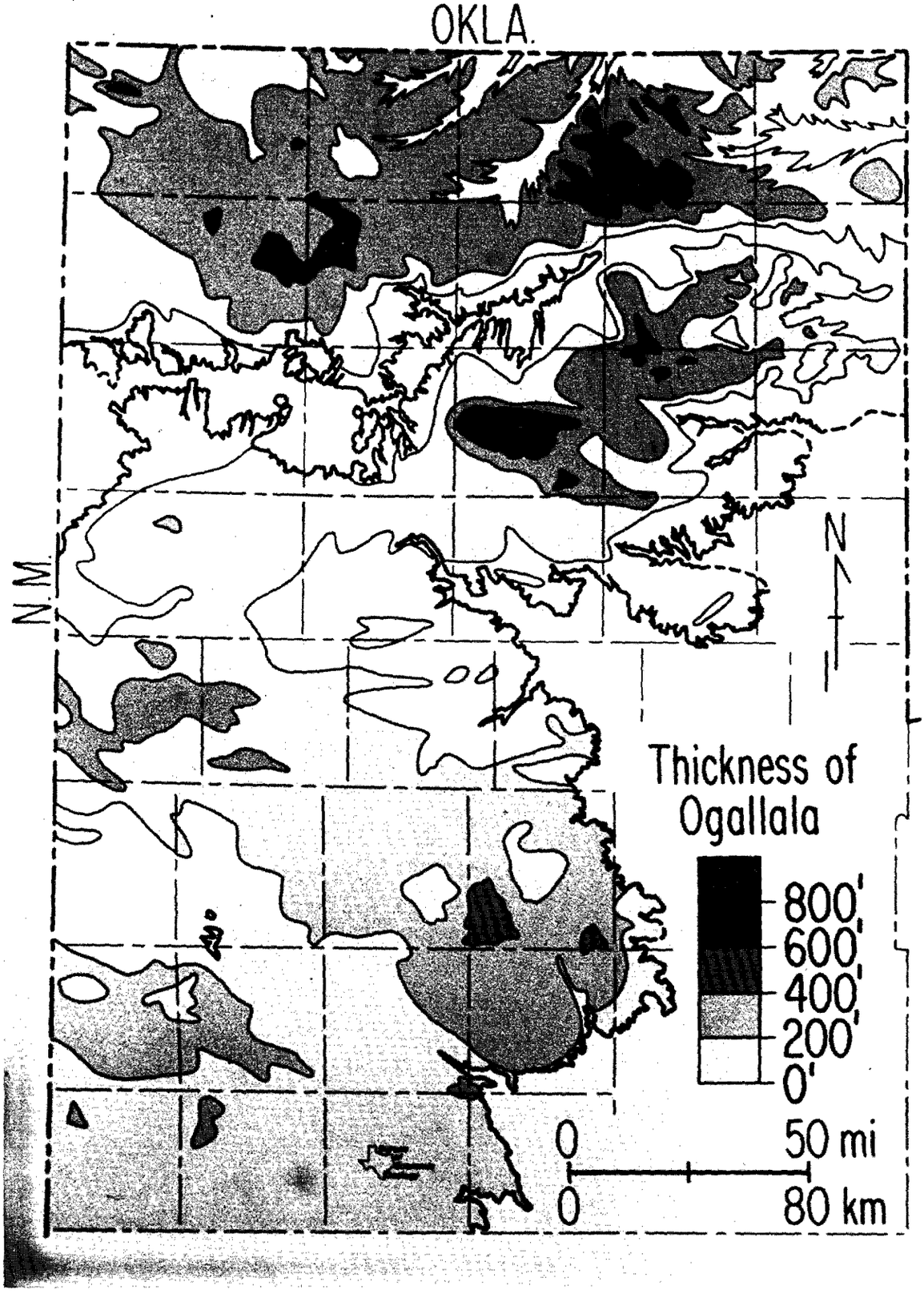
DISTRIBUTION OF BASEMENT TERRANES


DISTRIBUTION OF SEISMIC LINES AND WELL CONTROL
Oldham Co
Potter Co
Non-Proprietary seismic
Proprietary seismic
• Well control
Panhandle rhyolite
from Flawn, 1956
Muehlburger
and others 1967
Armstrong Co
Deaf Smith Co
Randall Co
Briscoe Co
TEXAS
0 10 20mi
0 20km
QA1894
Parmer Co
Castro Co
Swisher Co
Swisher diabase

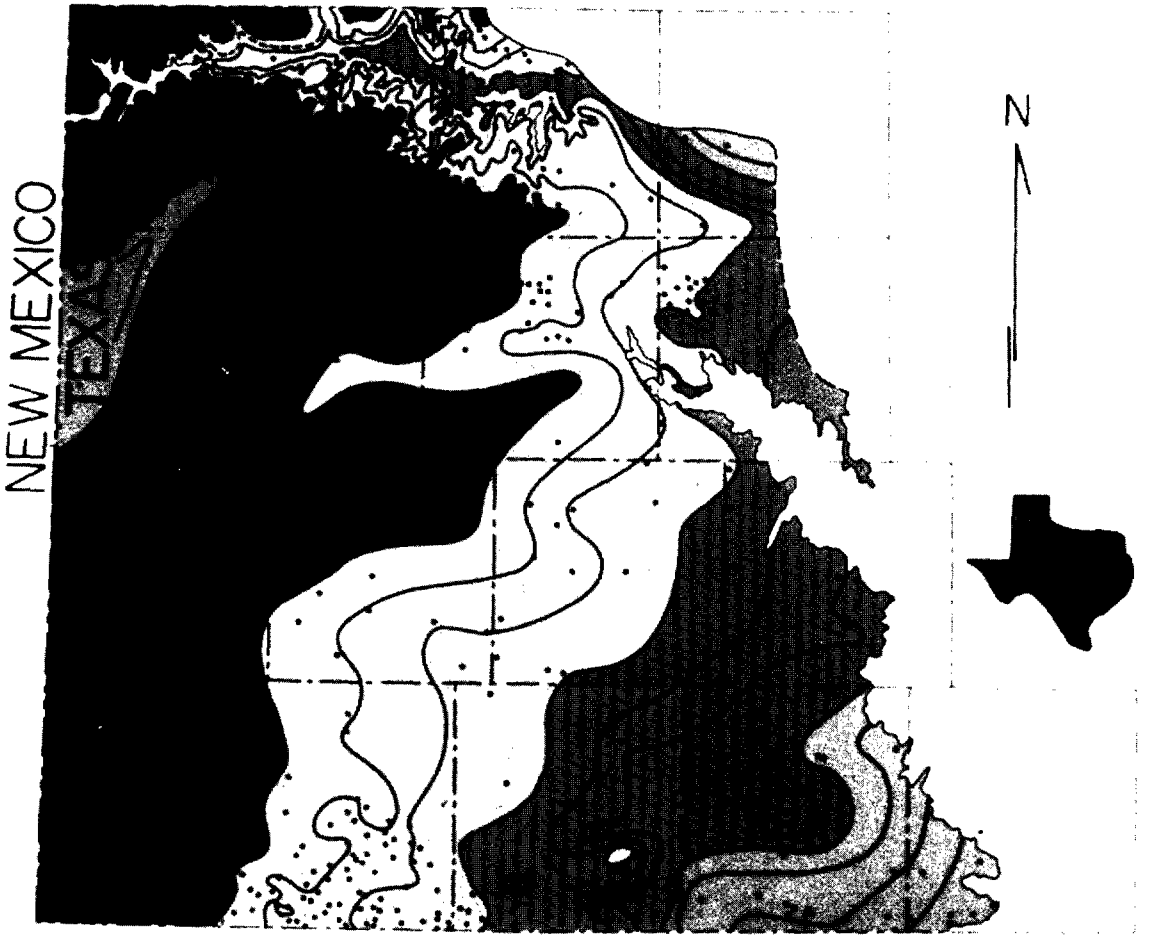

SP millivolts
Laterolog
(20)
-
+
0
500
0
5,000
Depth below kelly bushing (feet X 100)
87
88
89
106
107
108
109
110
111
121
122
Pennsylvanian
arkose
Rhyolite
Gabbro
Rhyolite
Hypothetical synthetic seismogram
Whittenburg
#1 Whittenburg-Masterson
Potter
0
30
0
30km
QA1897


SP millivolts
(10)
- +
Resistivity
10 100
0 1000
ohms m²/m
Depth below Kelly bushing (feet X 100)
71
72
73
74
75
76
77
Mississippian dolomite
Olivine diabase
Serpentinized dolomite
Olivine diabase
Meta-siltstone and serpentinized diopside-dolomite hornfels
Trachyte porphyry
H.L. Hunt
Ritchie #2
Briscoe
0 30mi
0 30km
from Flawn, 1956; Roth, 1960
QA1899
Bureau of Economic Geology


SP millivolts
(15)
- +
Resistivity
0
75 ohms m²/m
Depth below kelly bushing (feet X 100)
88
89
90
91
Mississippian dolomite
Ellenburger dolomite
Olivine diabase
Metamorphosed dolomite
Biotite diabase
Sandy metasiltstone
from Roth, 1960
QA1898
Bureau of Economic Geology
Sun Oil Co
Haberer #1
0 30mi
0 30km


OKLA.
N.M.
N
Thickness of
Ogallala
800'
600'
400'
200'
0'
0
50 mi
0
80 km

STRUCTURE CONTOUR
TOP OF DOCKUM GROUP



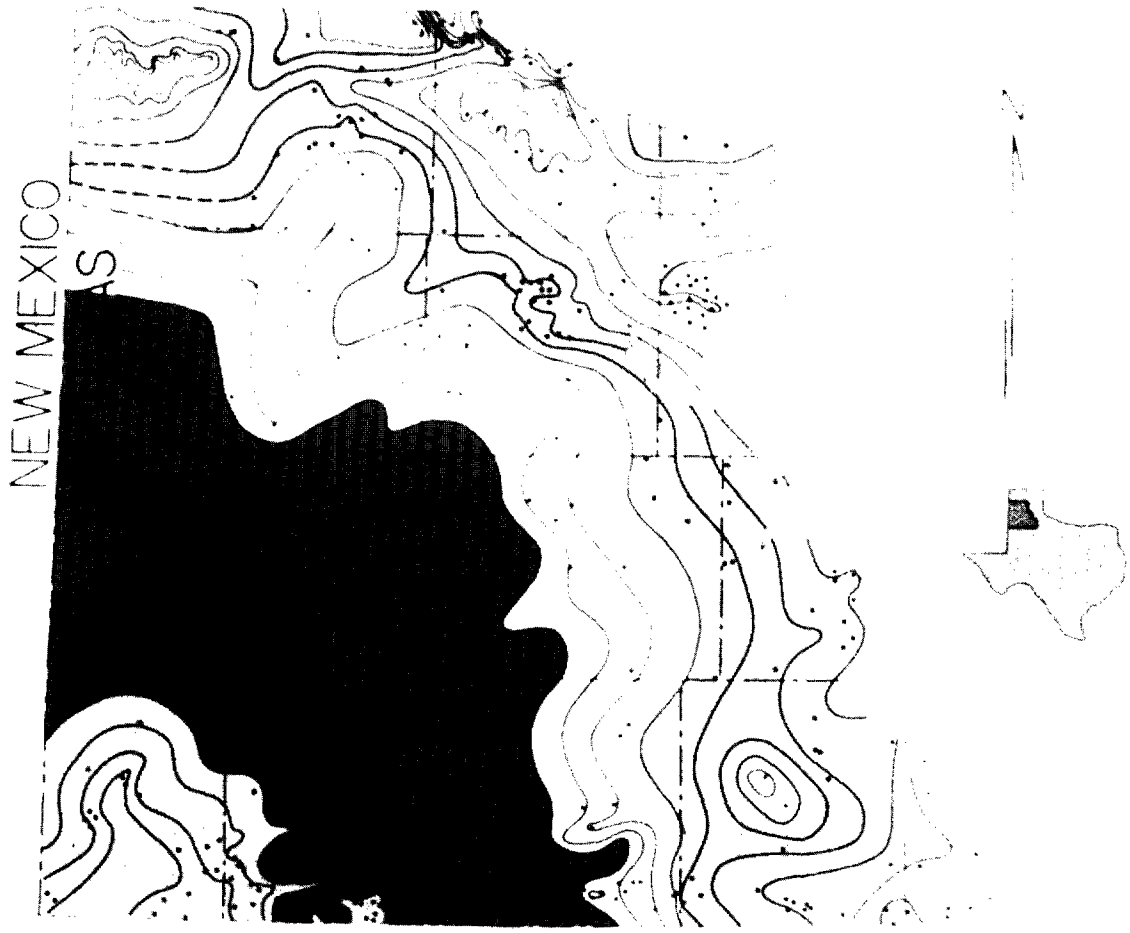
< 2900ft
2900-3200
3200-3500
3500-3800
3800-4100
> 4100

0 40mi
0 40km

Contour interval = 100ft

QA-1907

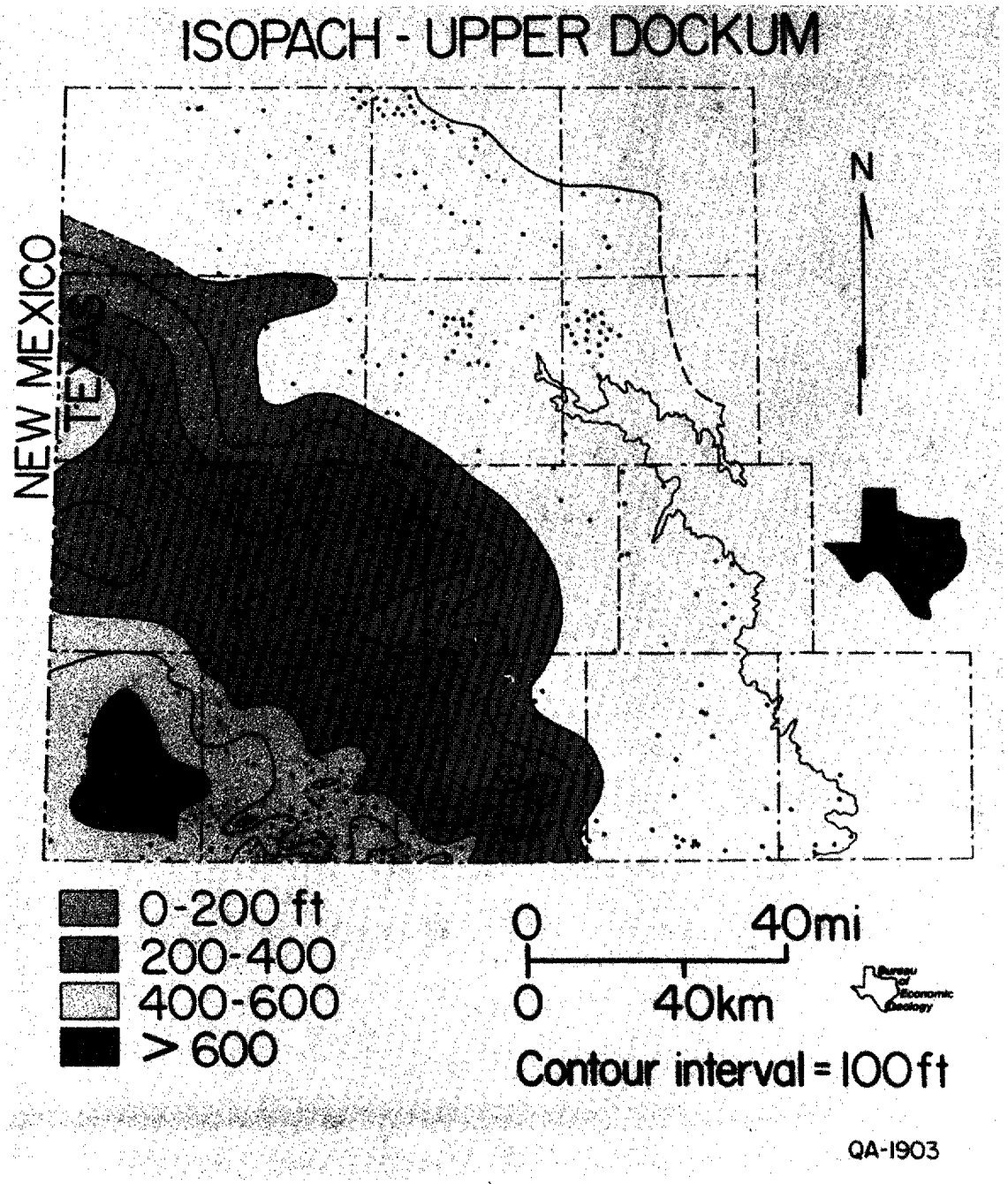
ISOPACH - DOCKUM GROUP



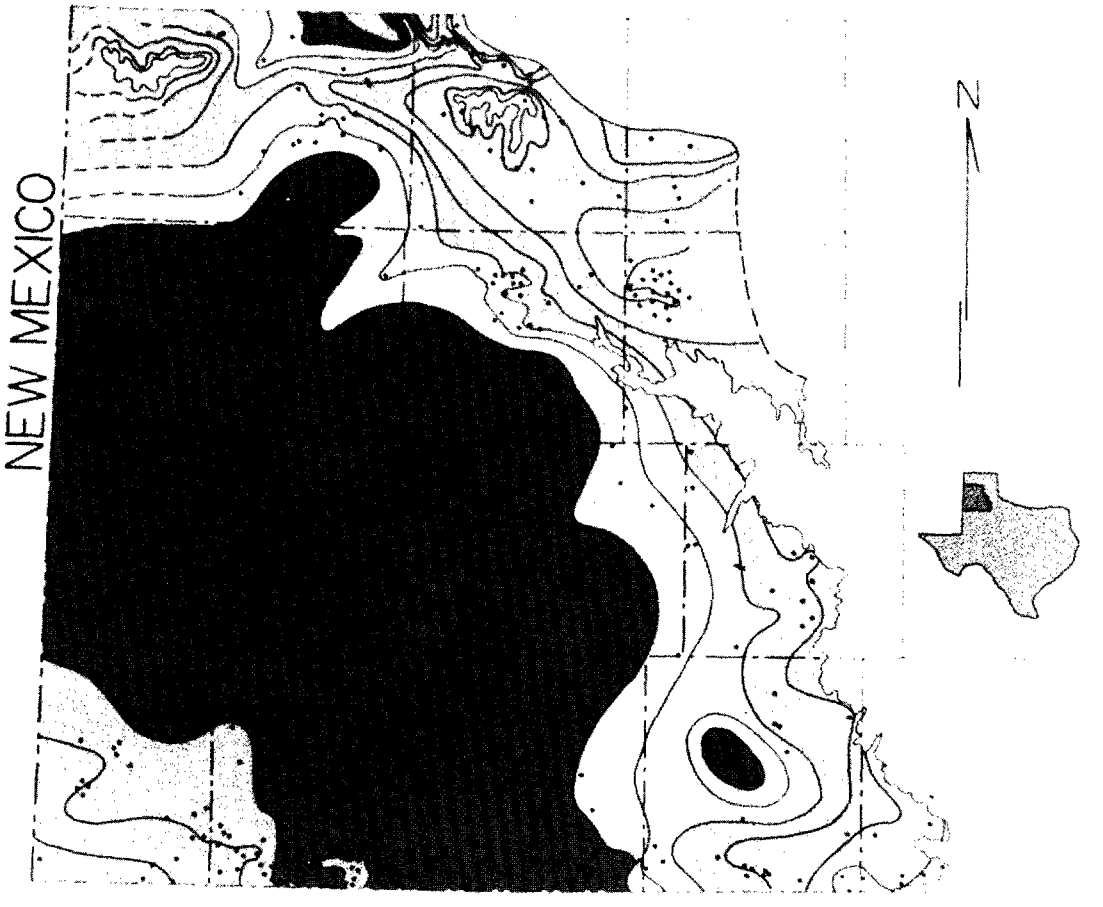
0-300 ft
300-600
600-900
900-1200
1200-1500
>1500

0 40mi
0 40km

Contour interval = 100ft


ISOPACH - UPPER DOCKUM
NEW MEXICO
TEXAS
N
0-200 ft
200-400
400-600
> 600
0
40mi
0
40km
Bureau of Economic Geology
Contour interval = 100 ft
QA-1903

ISOPACH - LOWER DOCKUM

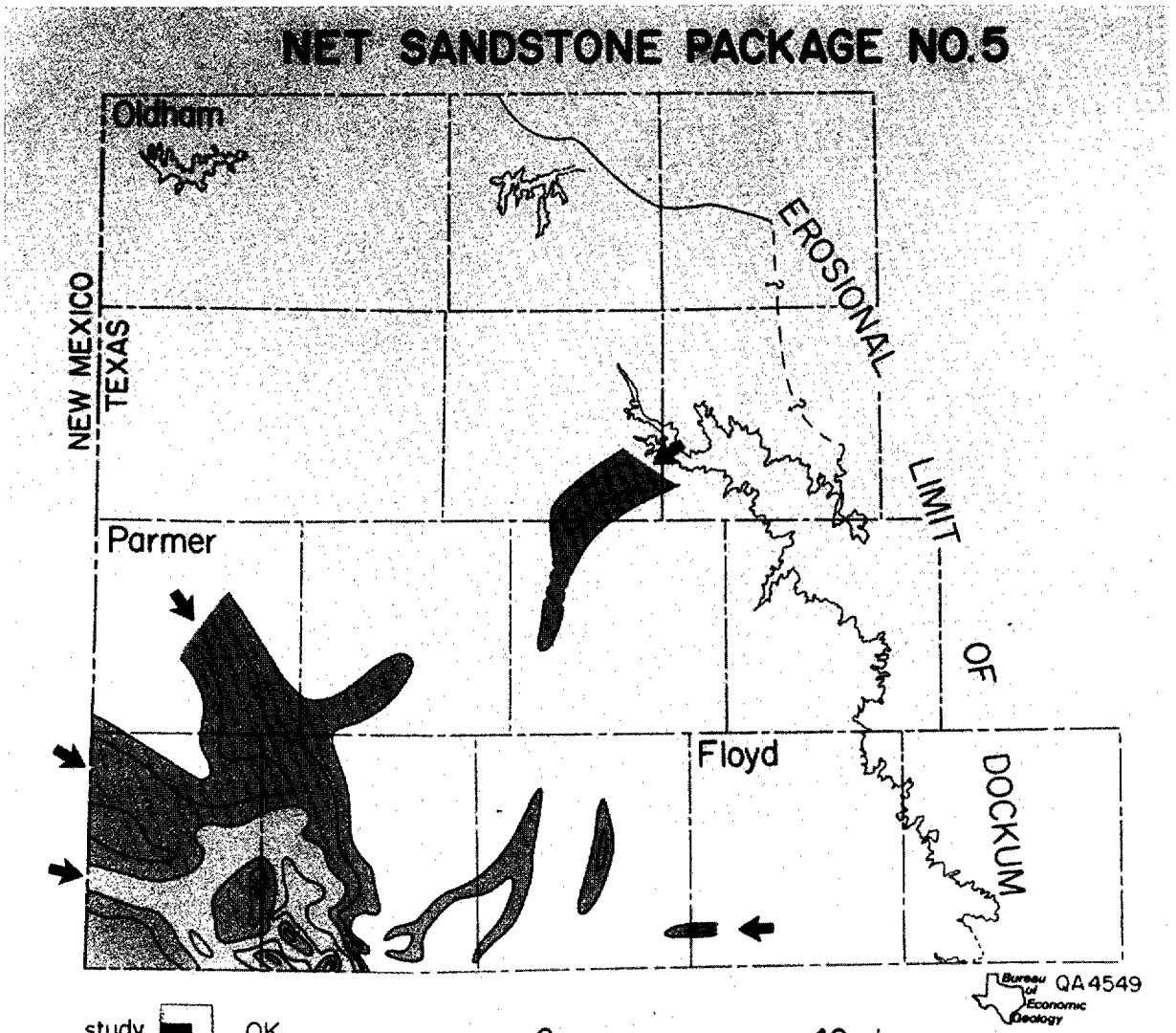


0-200 ft
200-400
400-600
600-800
800-1000
1000-12000
> 1200

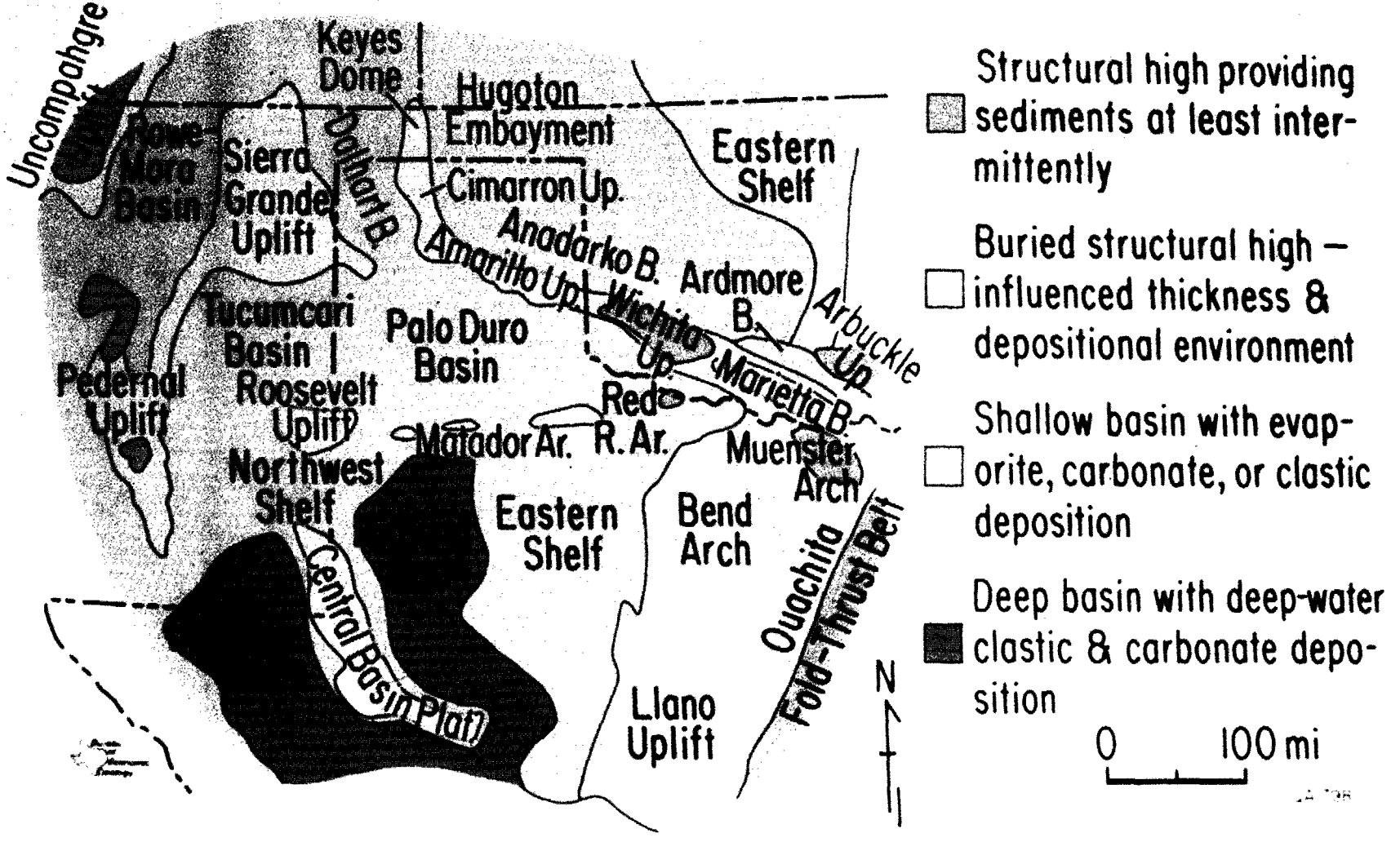
0 40mi
0 40km

Contour interval = 100'

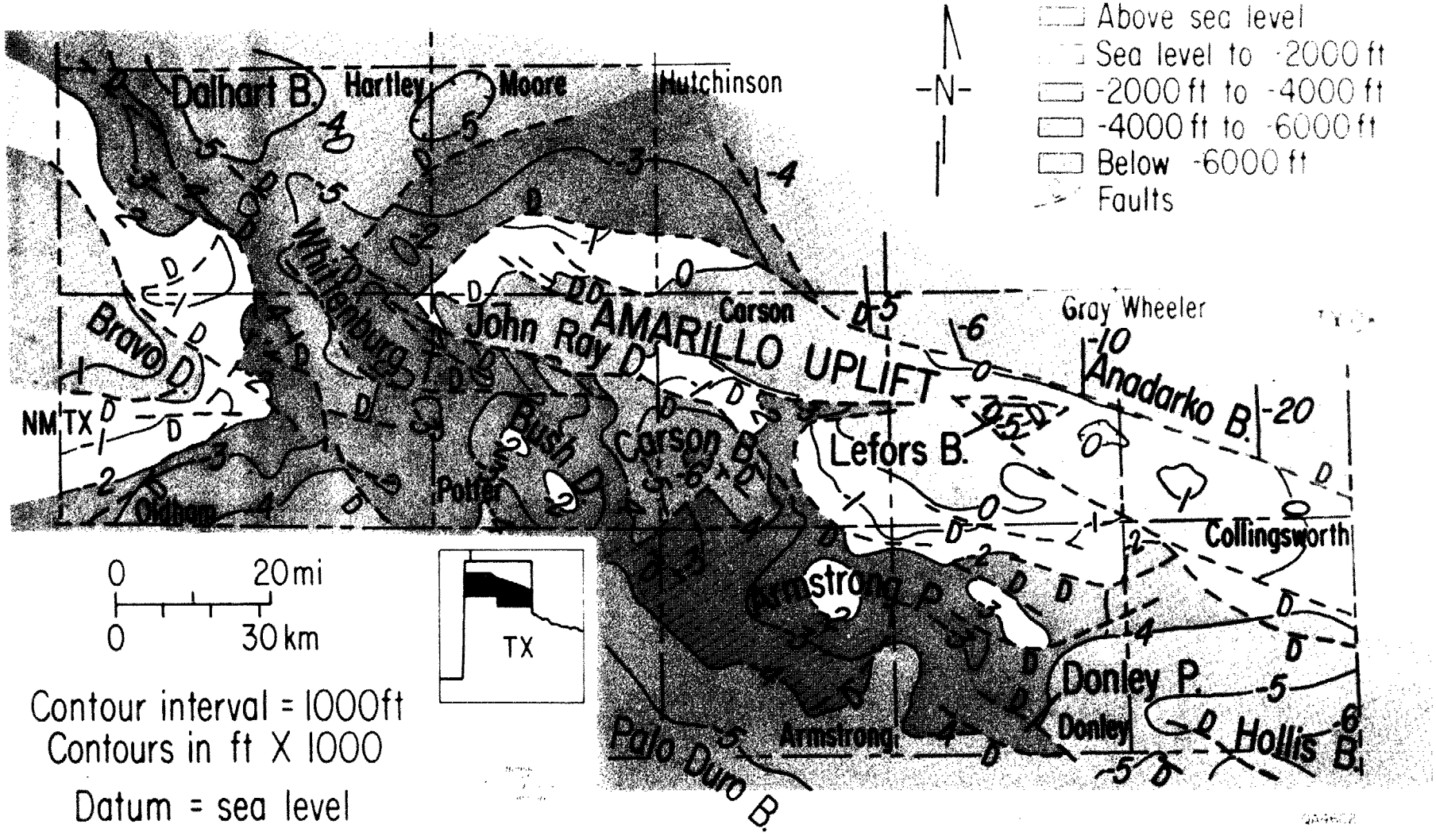
QA-1905


NET SANDSTONE PACKAGE NO.5
Oldham
NEW MEXICO
TEXAS
EROSIONAL
LIMIT
OF
DOCKUM
Parmer
Floyd
QA4549
Bureau of Economic Geology
study area
OK
N.M.
TX
N
0
40mi
0
40km
contour interval = 20ft
EXPLANATION
0-20
20-60
60-100
>100

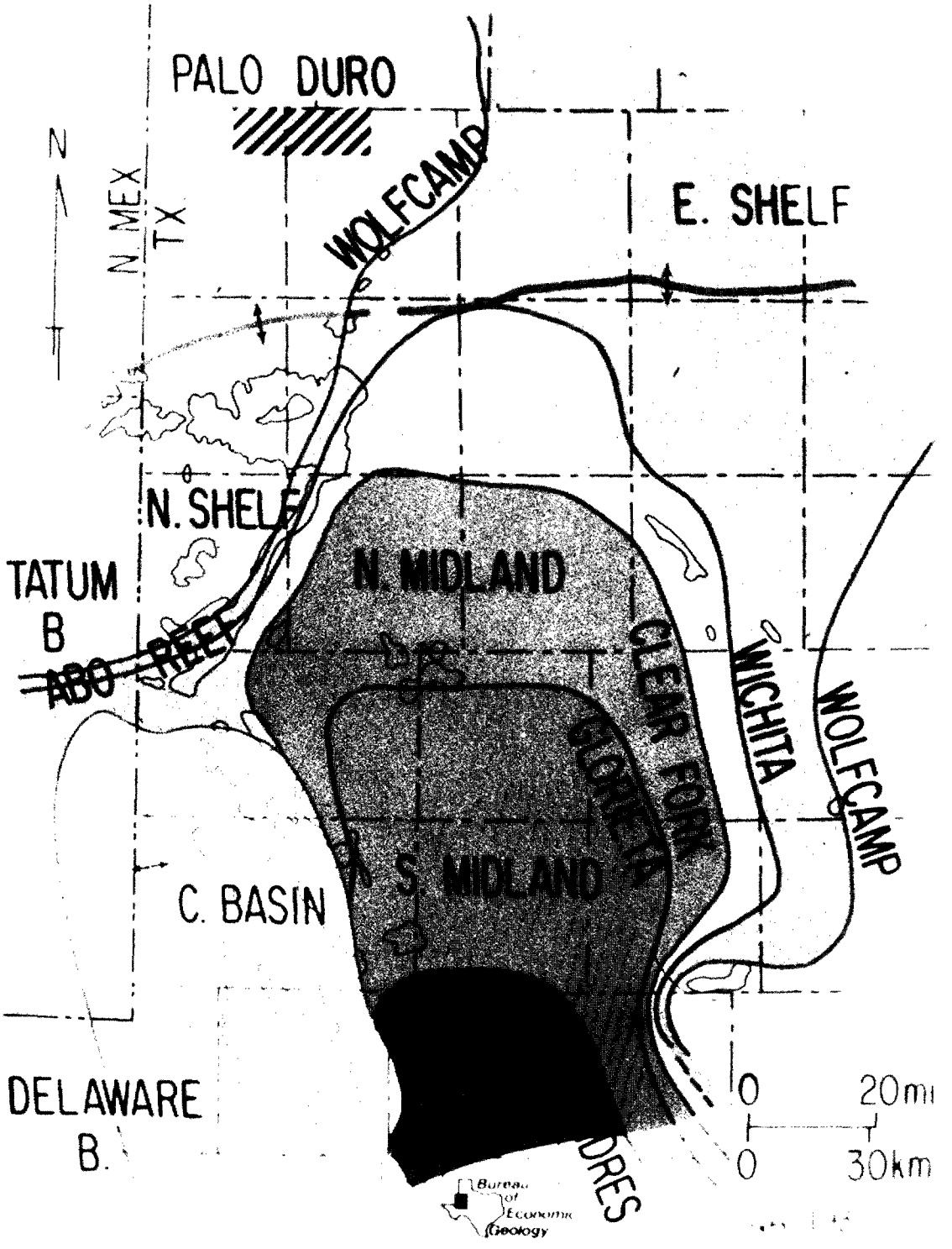
MIDDLE & LATE PERMIAN TECTONIC ELEMENTS



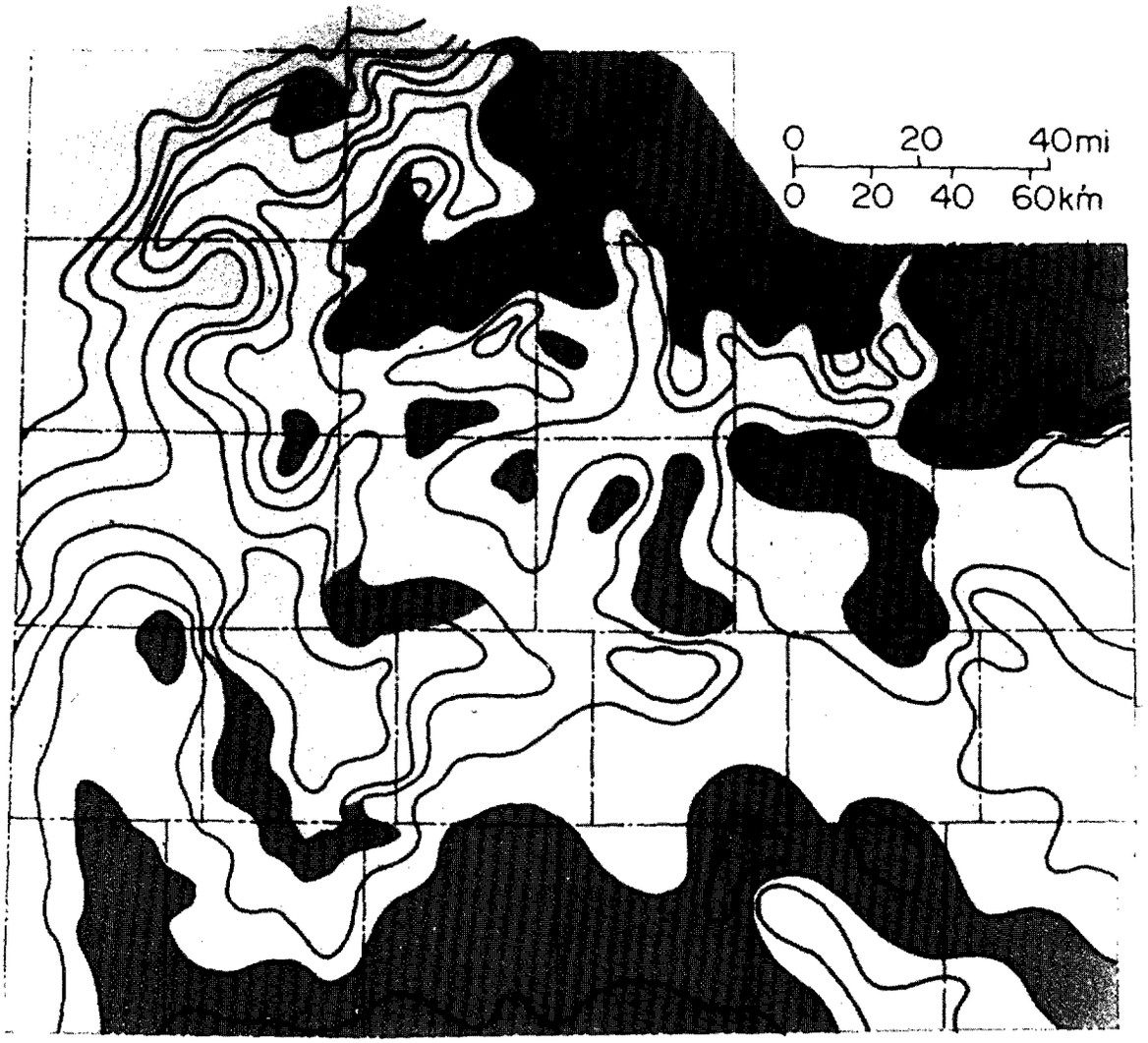
Basement structure map of Amarillo Uplift



PROGRADATION OF PERMIAN SHELF MARGIN SOUTHERN TEXAS PANHANDLE



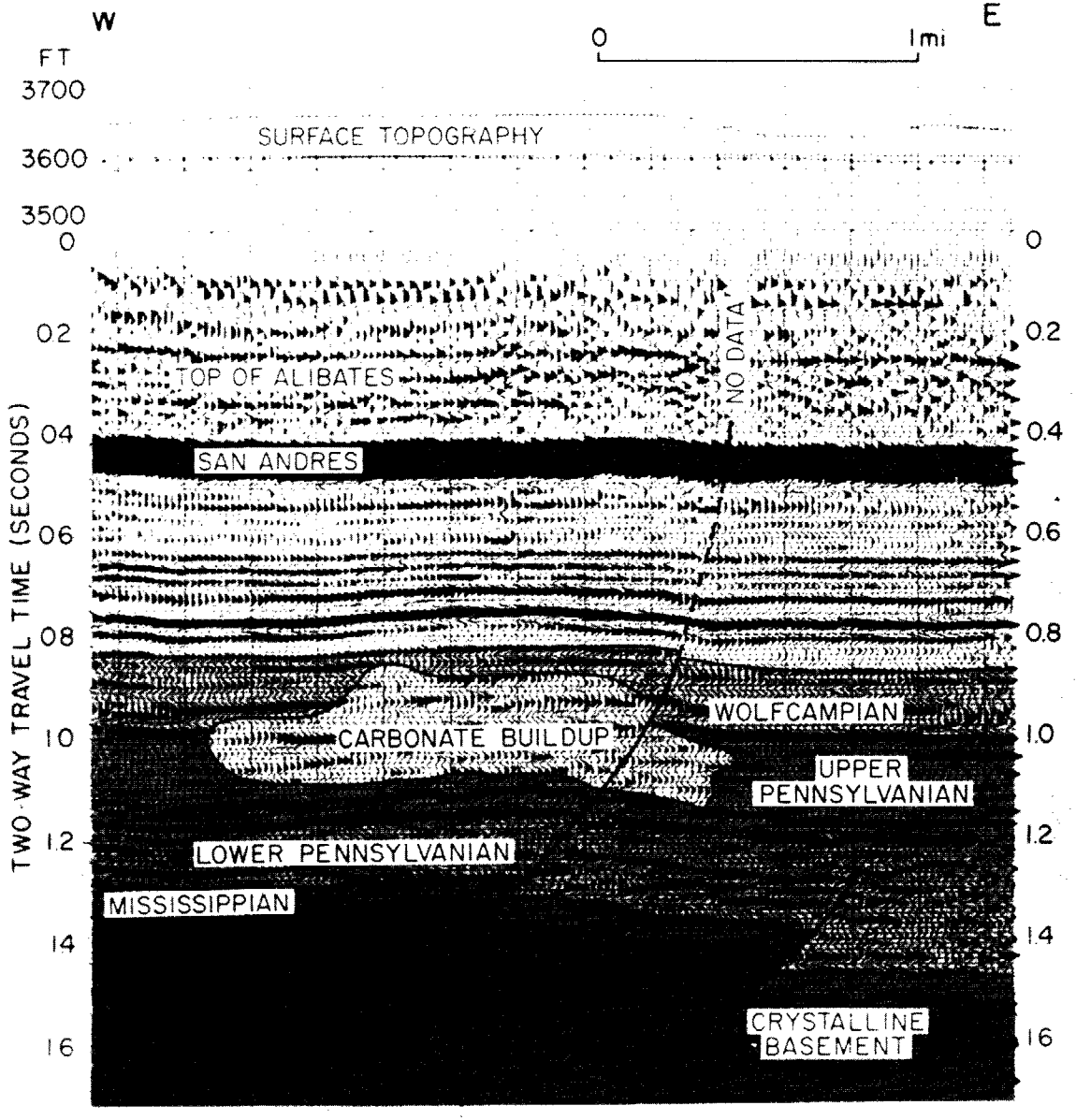
GENERALIZED LITHOFACIES - WICHITA GROUP



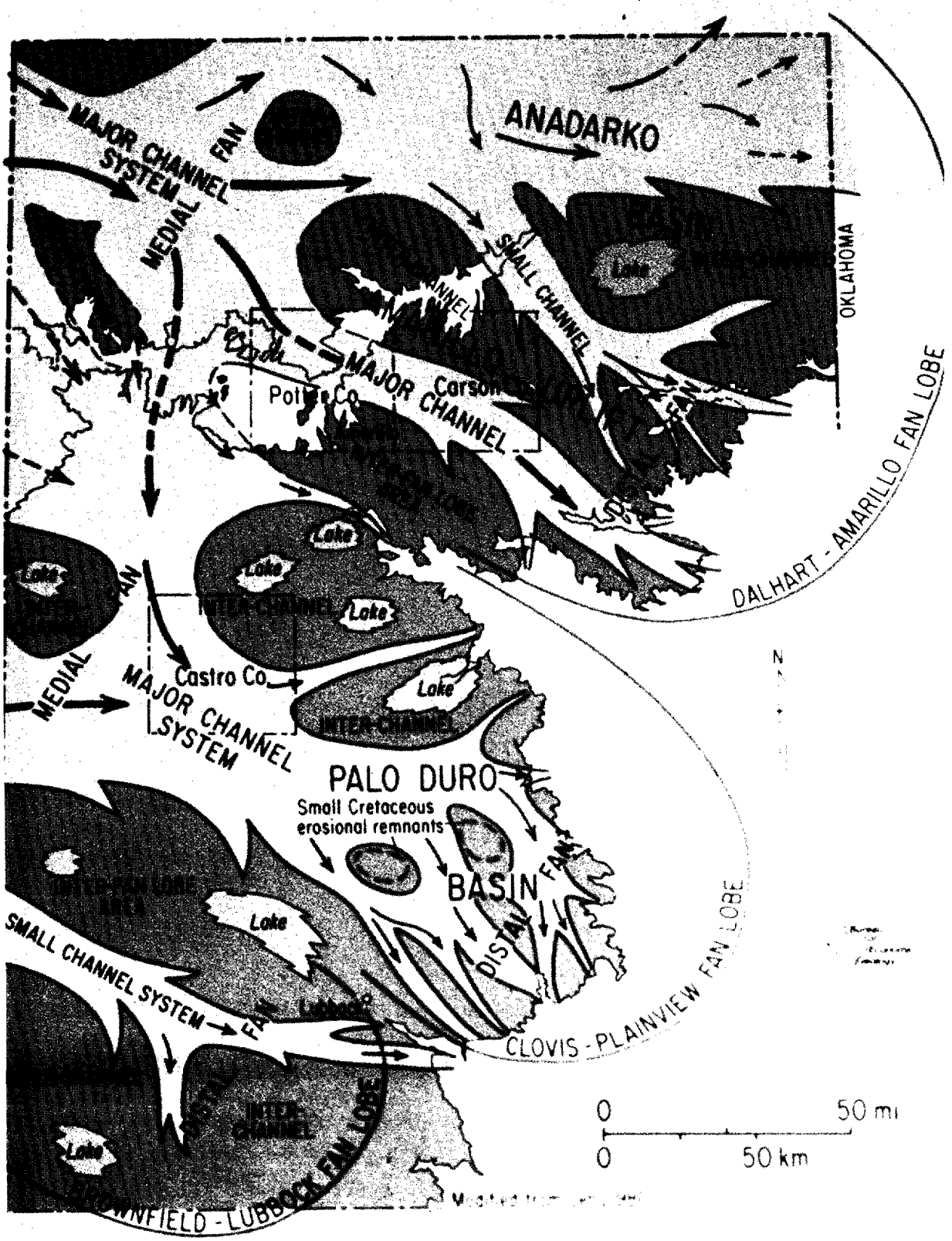
>80% CARB
>60% CARB
40-60% CARB ANHY > CLASTICS
40-60% CARB CLASTICS > ANHY
<40% CARB ANHY > CLASTICS
<40% CARB CLASTICS > ANHY

%CARB (=DOLOMITE)
CI = 10%

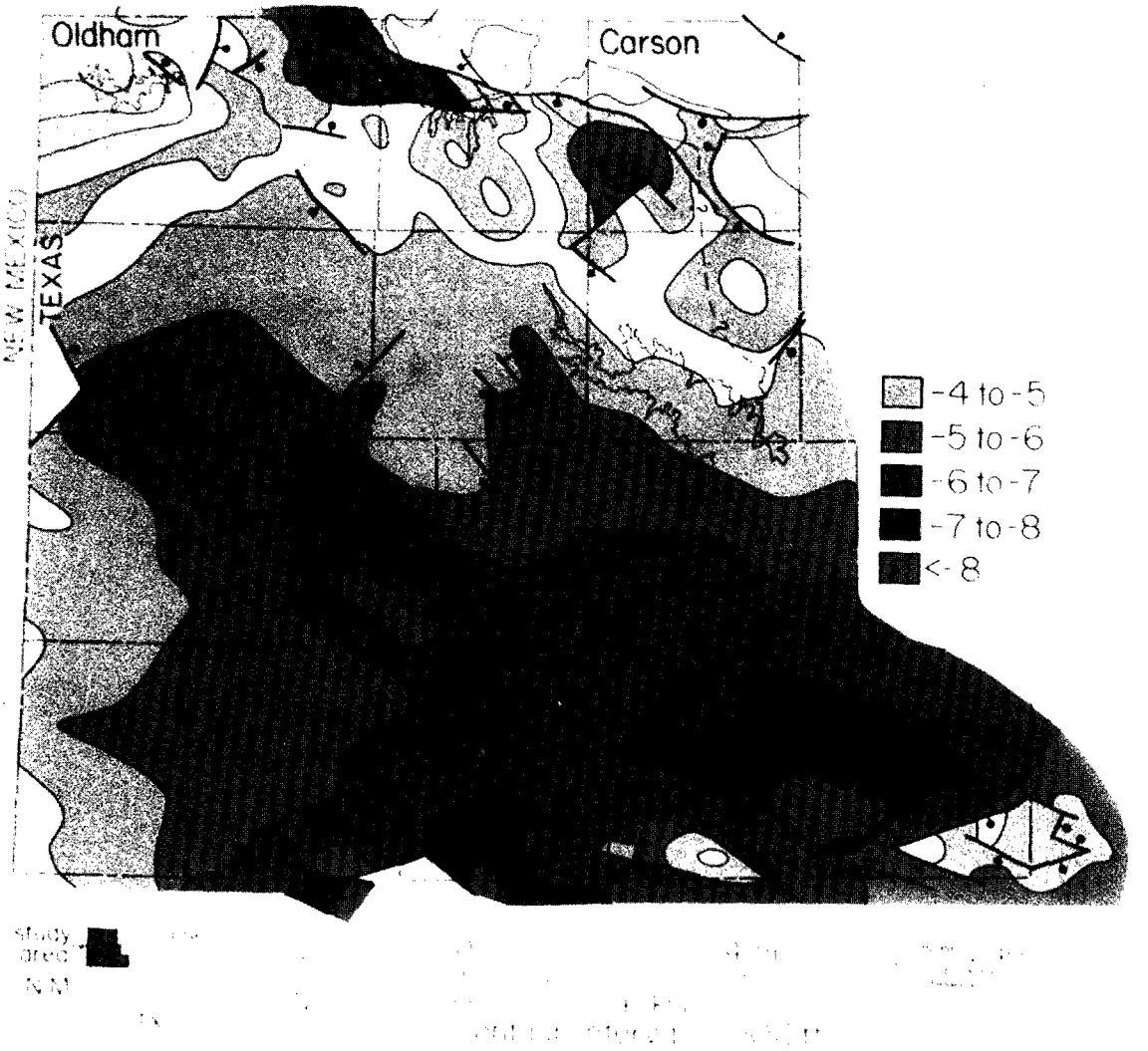
QA817


W
E
0
1 mi
FT
3700
3600
3500
SURFACE TOPOGRAPHY
0
02
04
06
08
10
12
14
16
TWO-WAY TRAVEL TIME (SECONDS)
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
NO DATA
TOP OF ALIBATES
SAN ANDRES
WOLFCAMPIAN
CARBONATE BUILDUP
UPPER PENNSYLVANIAN
LOWER PENNSYLVANIAN
MISSISSIPPIAN
CRYSTALLINE BASEMENT

DEPOSITIONAL PATTERNS OF OGALLALA FM



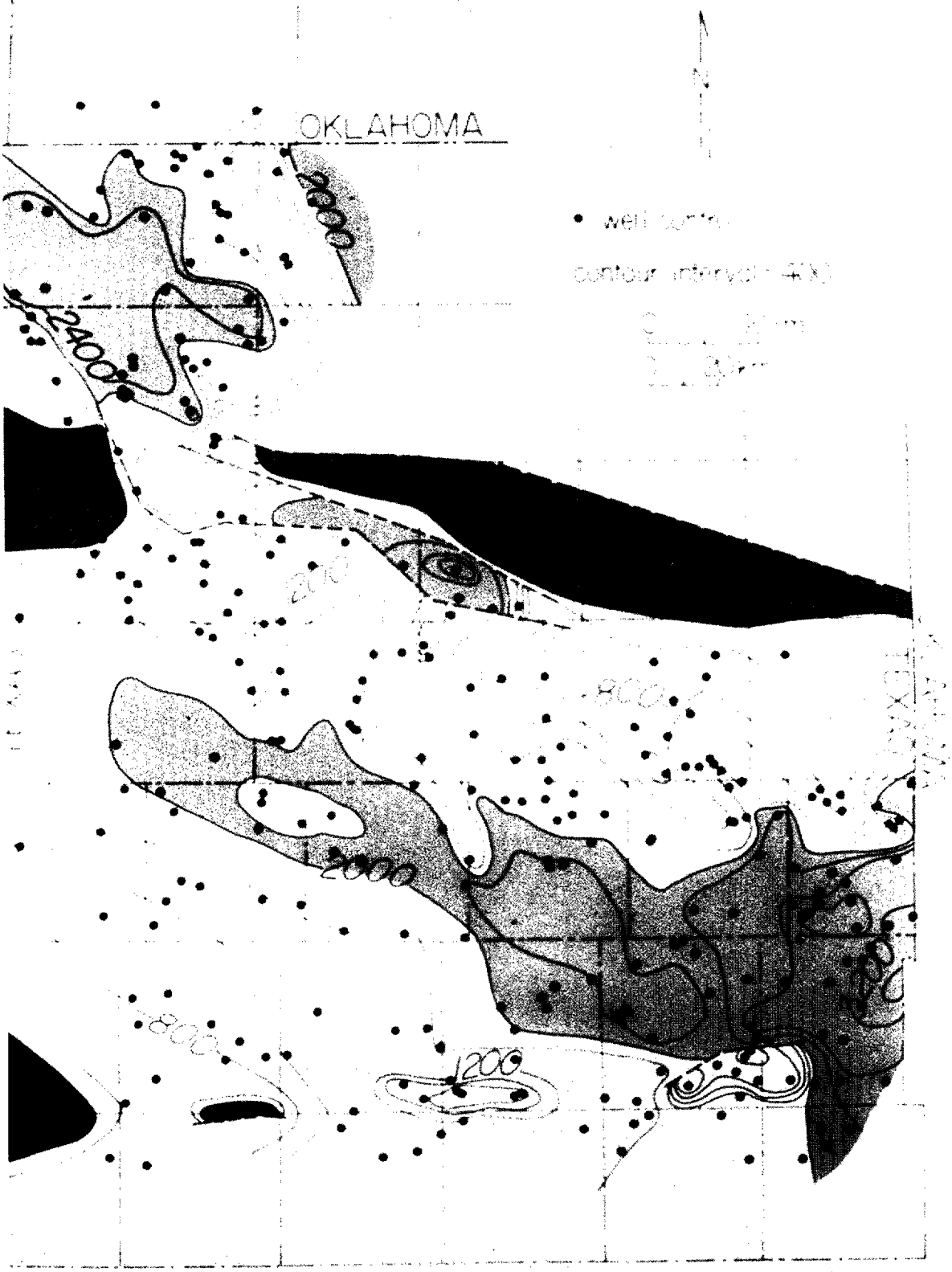
SIMPLIFIED BASEMENT STRUCTURE



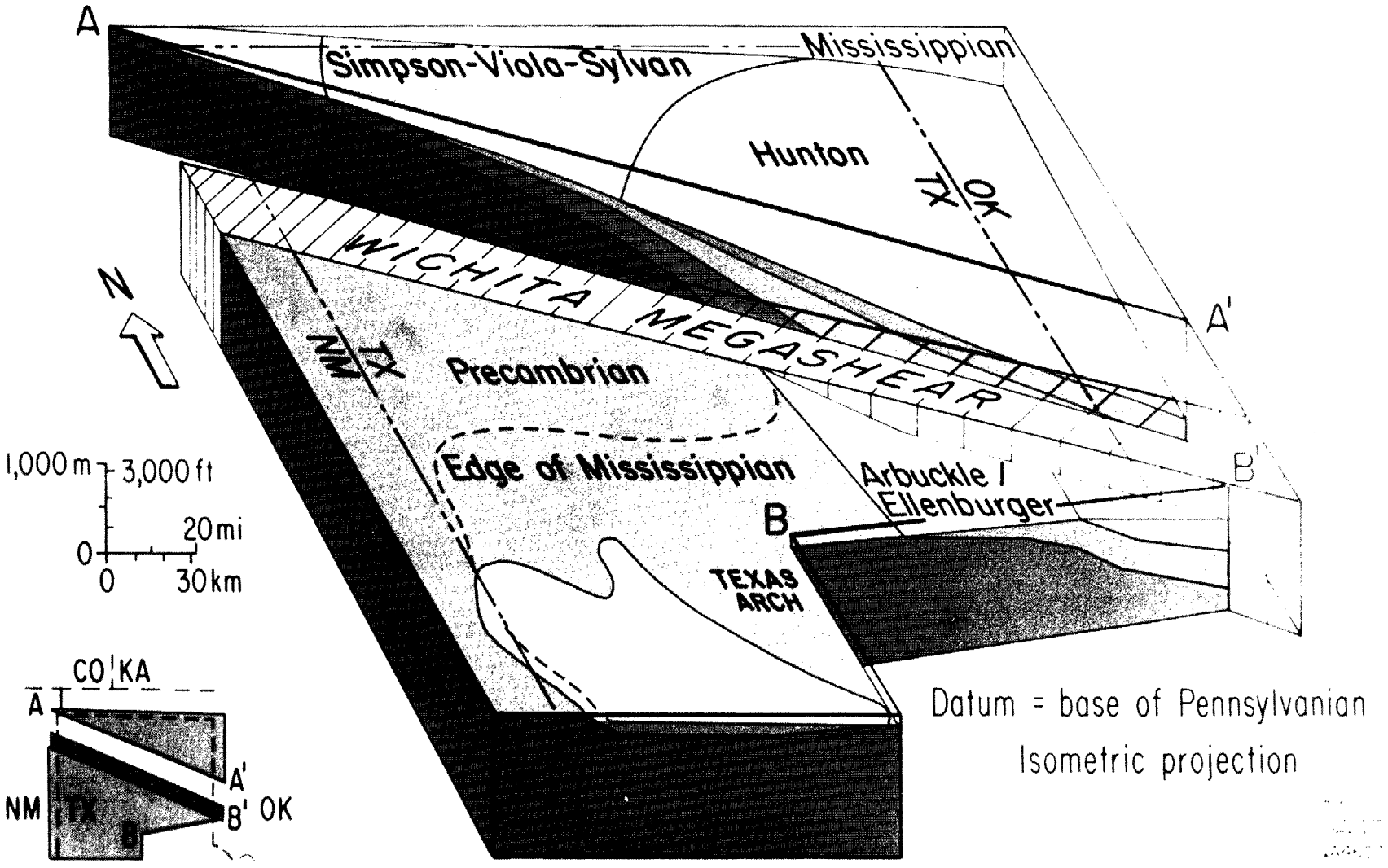
EXPLANATION

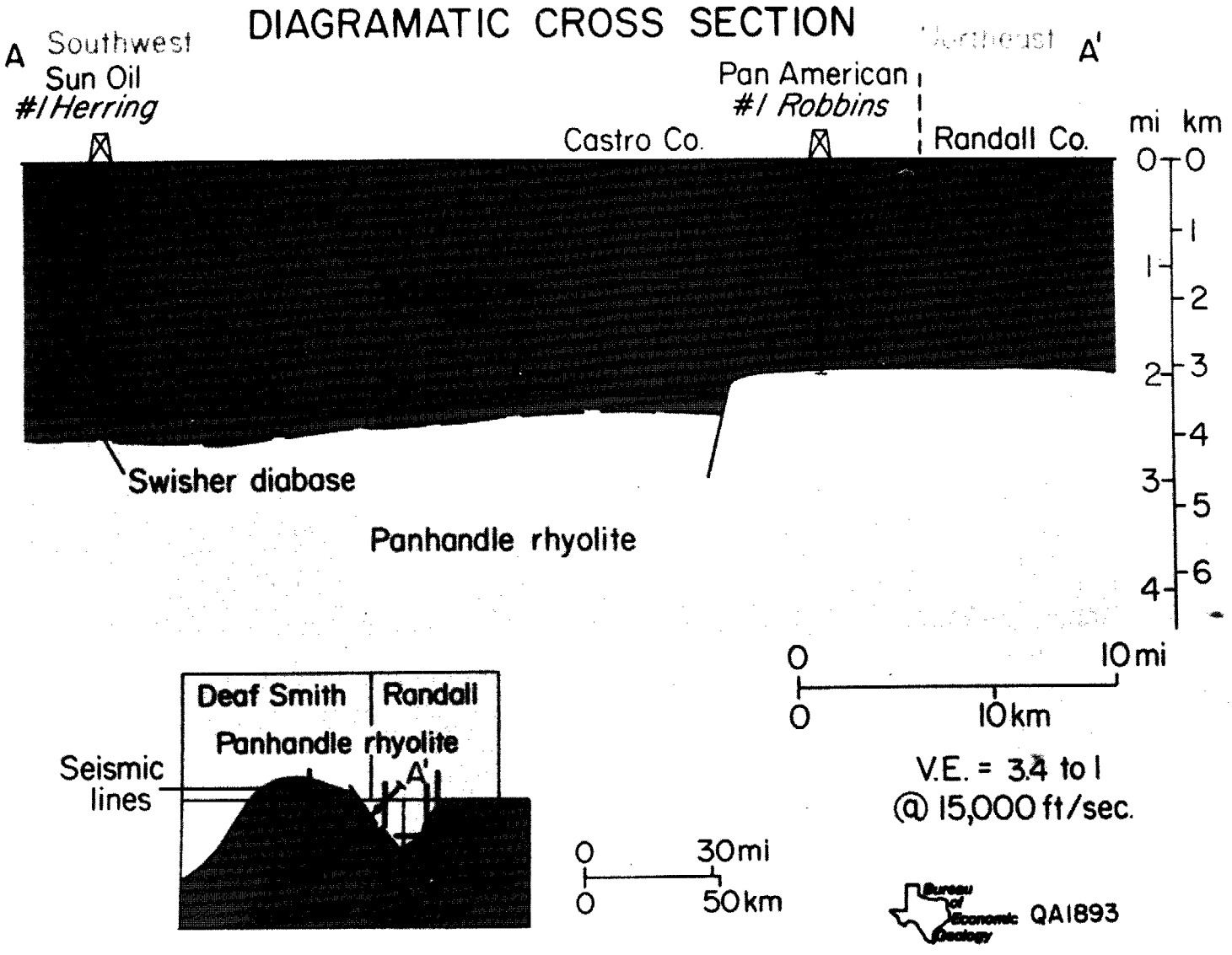
(from Budnik, 1984)

THICKNESS OF PENNSYLVANIAN

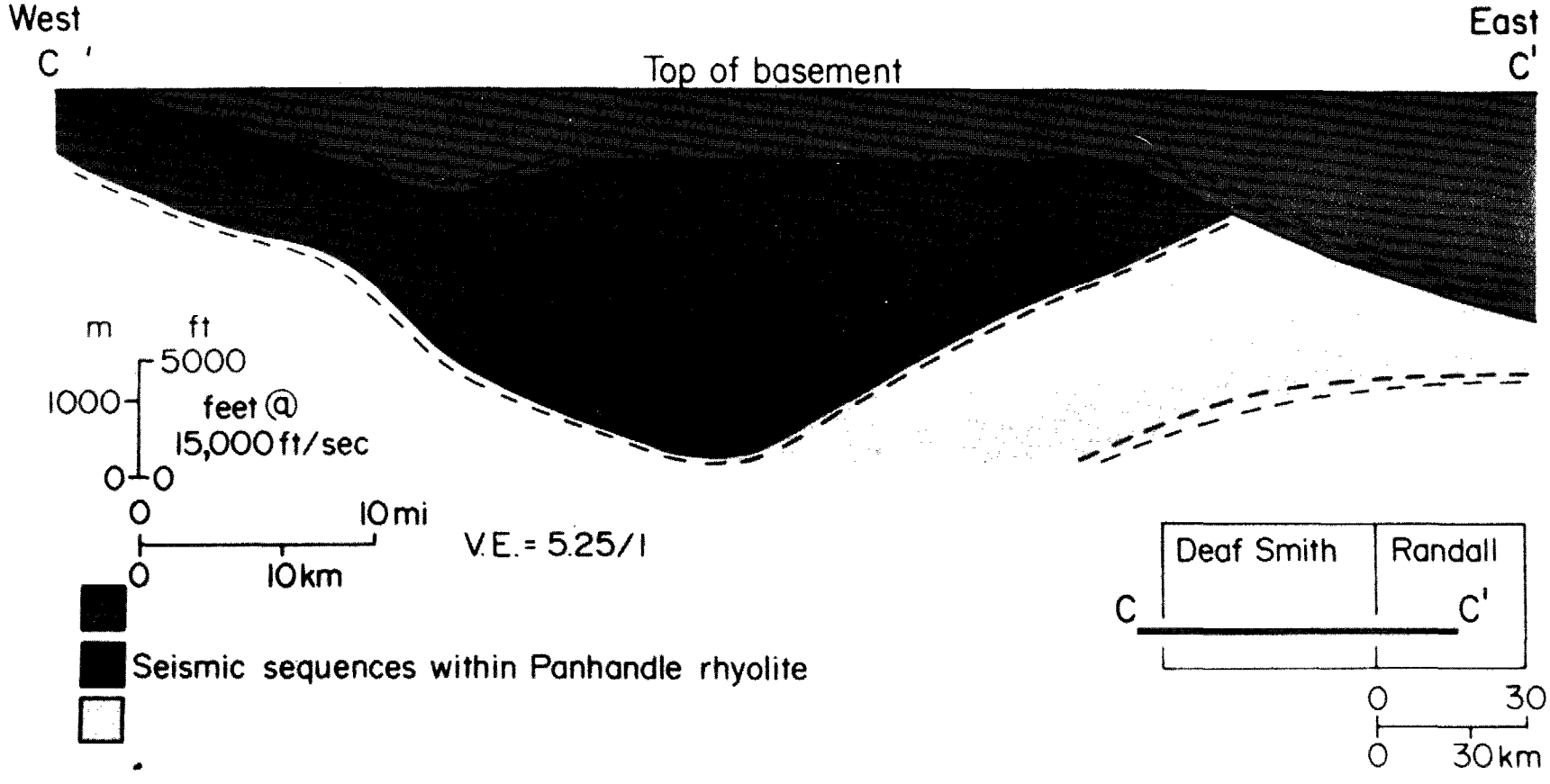


Schematic block diagram of the Texas Panhandle



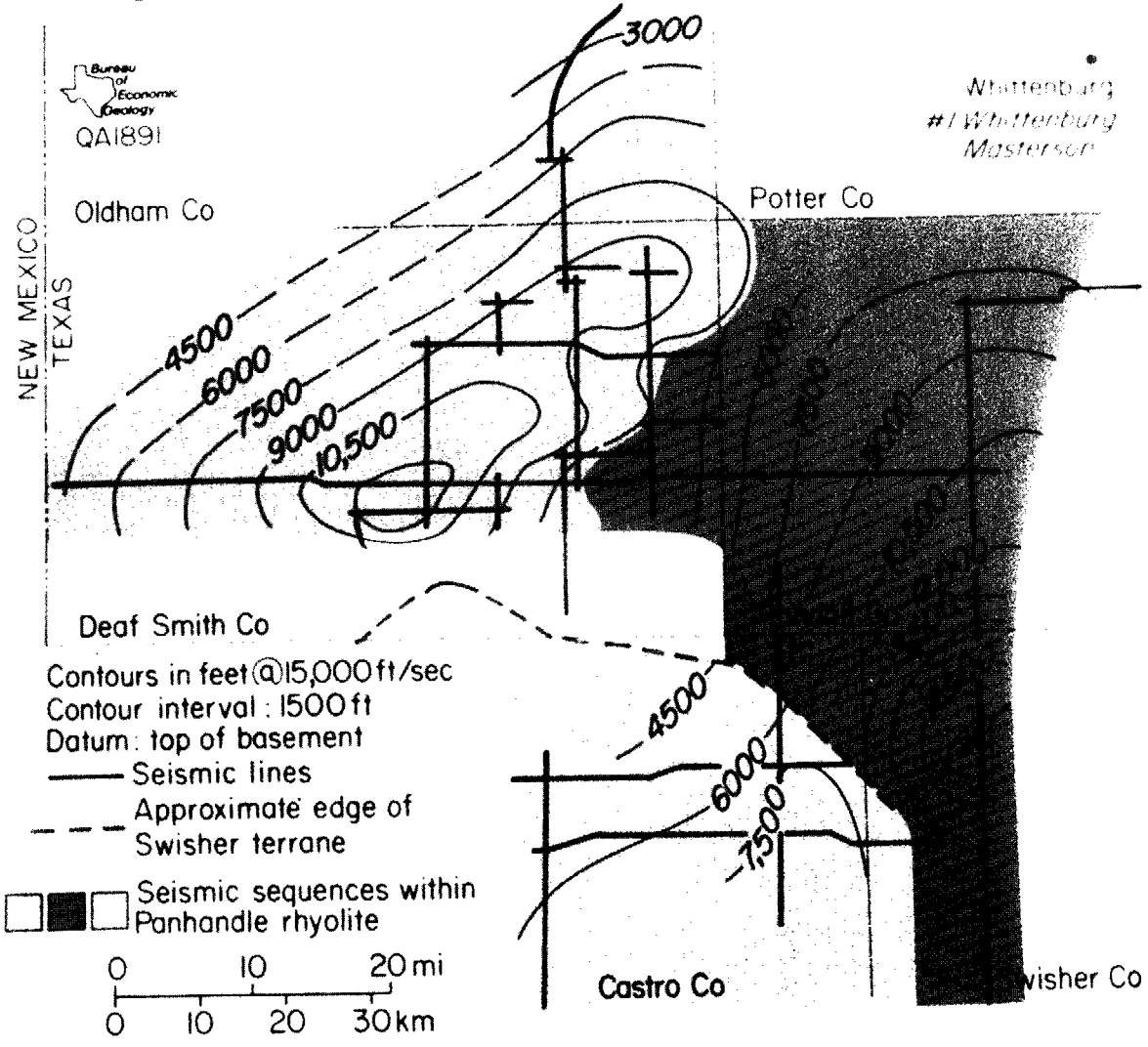

DIAGRAMATIC CROSS SECTION
A
Southwest
Sun Oil
#1 Herring
Northeast
A'
Pan American
#1 Robbins
Castro Co.
Randall Co.
mi km
0 0
1 1
1 2
2 3
2 4
3 5
3 6
4
Swisher diabase
Panhandle rhyolite
0 10 mi
0 10 km
V.E. = 3.4 to 1
@ 15,000 ft/sec.
Deaf Smith
Randall
Panhandle rhyolite
A'
Seismic lines
0 30 mi
0 50 km
QA1893

SEISMIC-DERIVED CROSS-SECTION

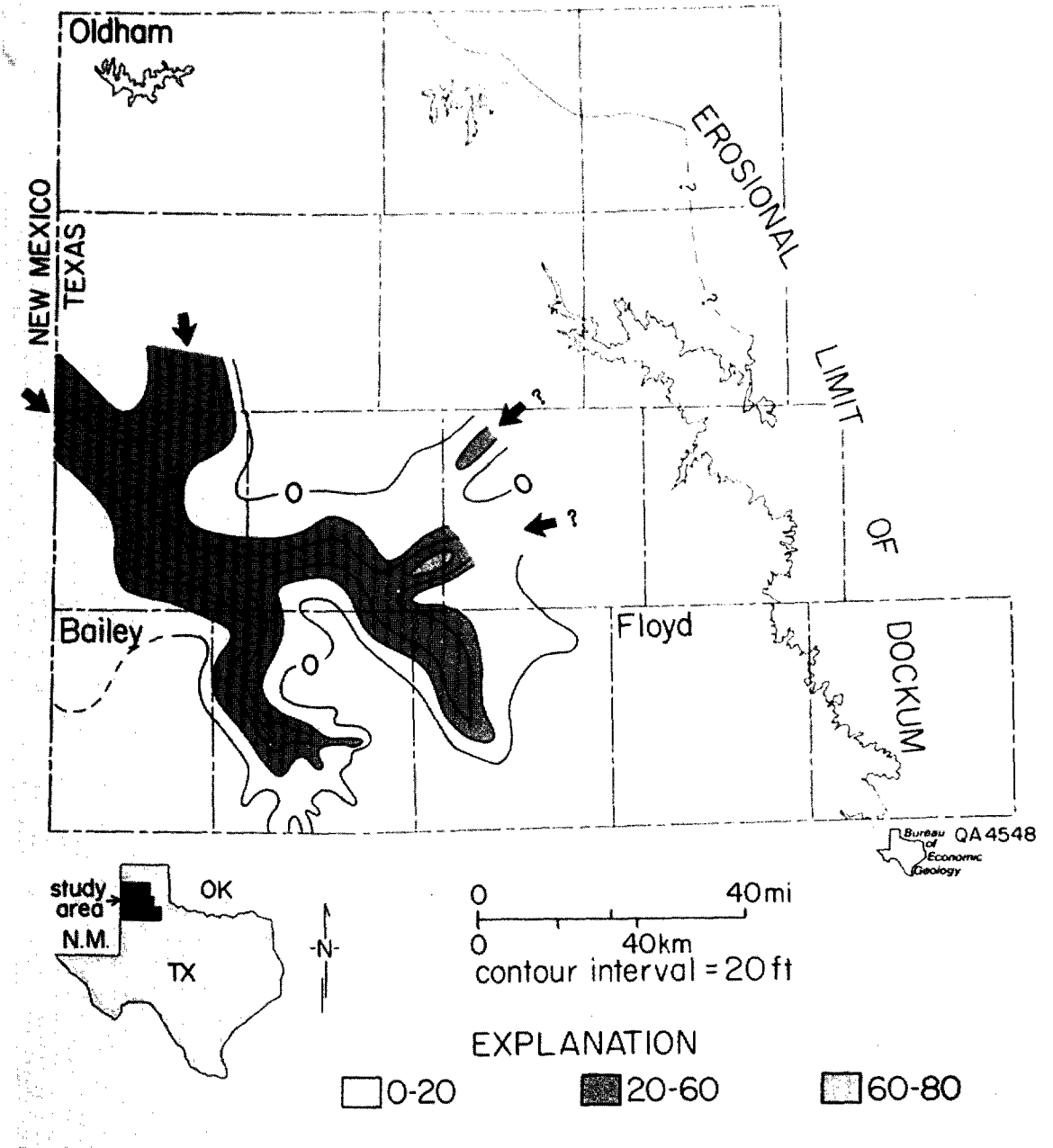


Bureau of Economic Geology QA1895

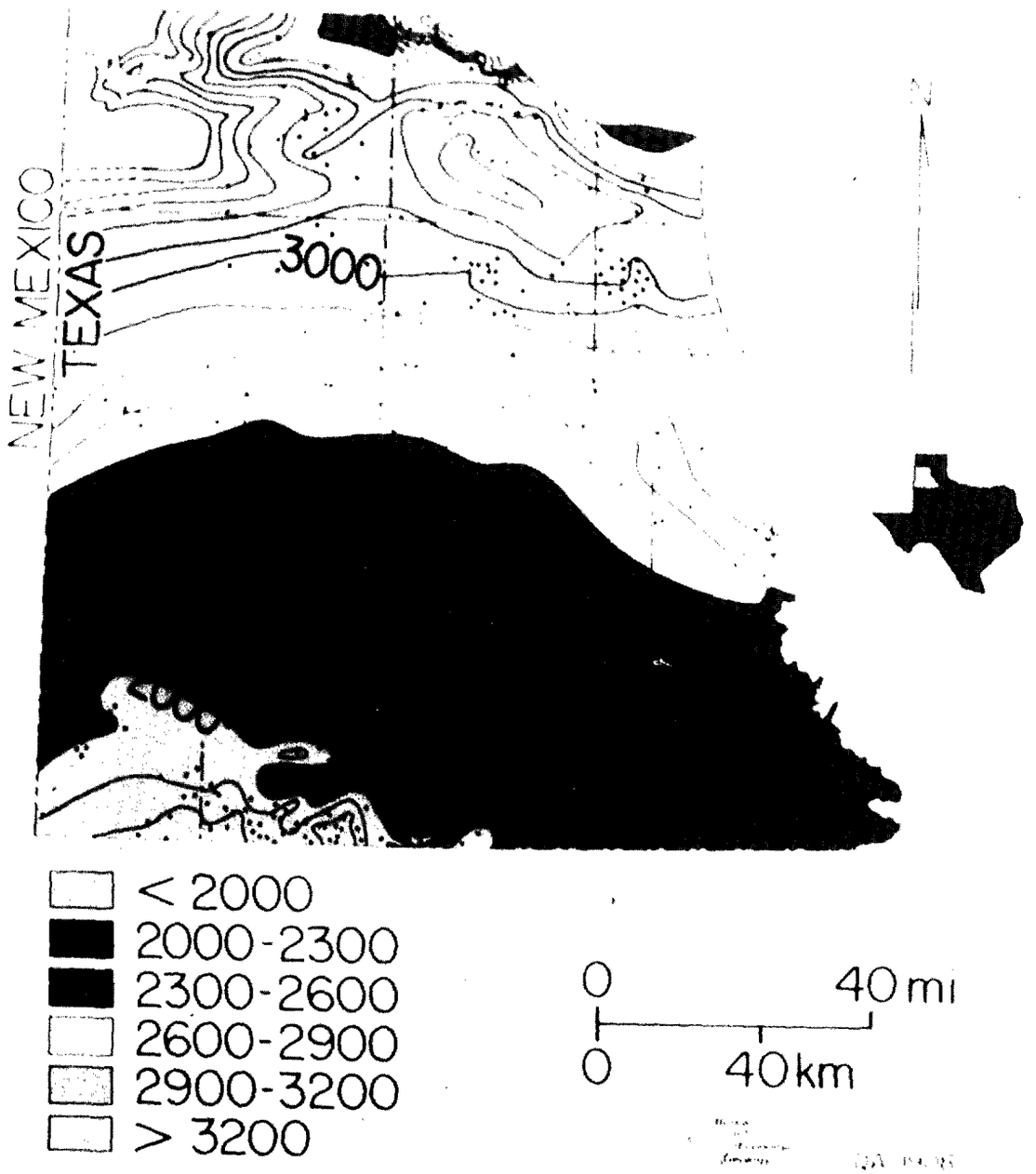
STRUCTURE ON BASE OF SEISMIC SEQUENCES



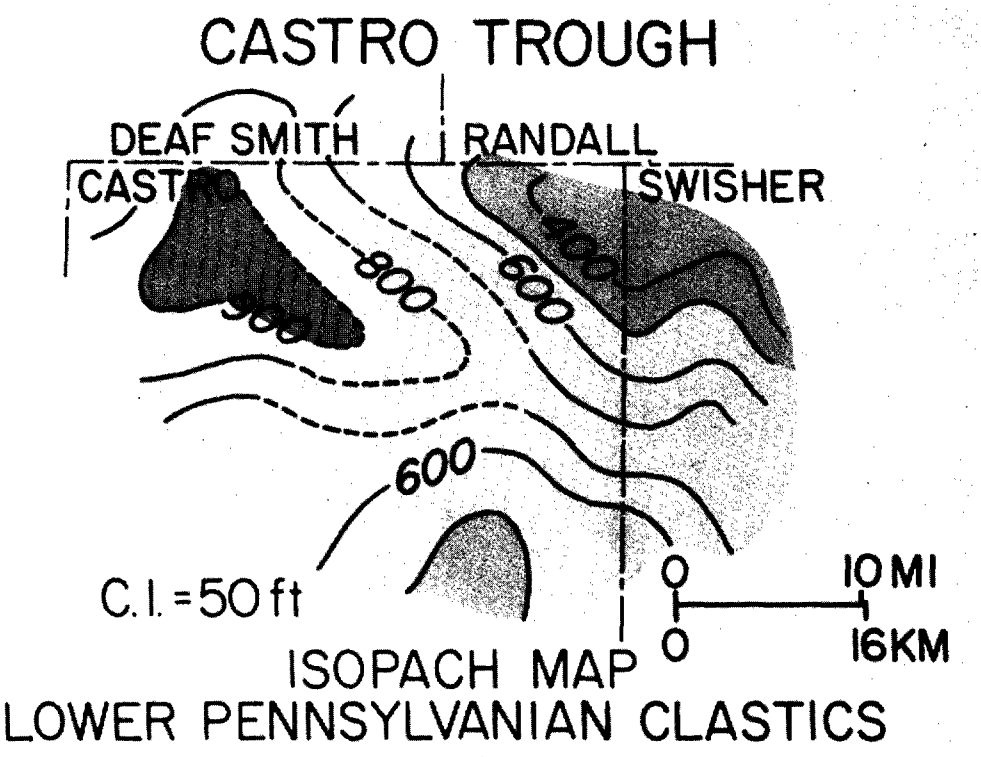
NET SANDSTONE PACKAGE NO. 4



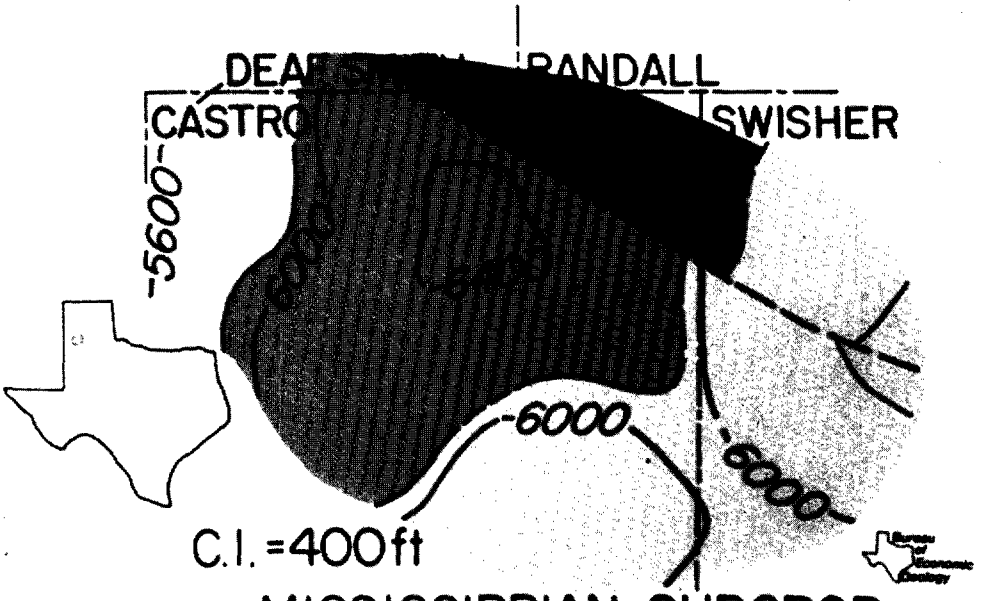
STRUCTURE CONTOUR
BASE OF DOCKUM GROUP



Contour interval = 100 ft



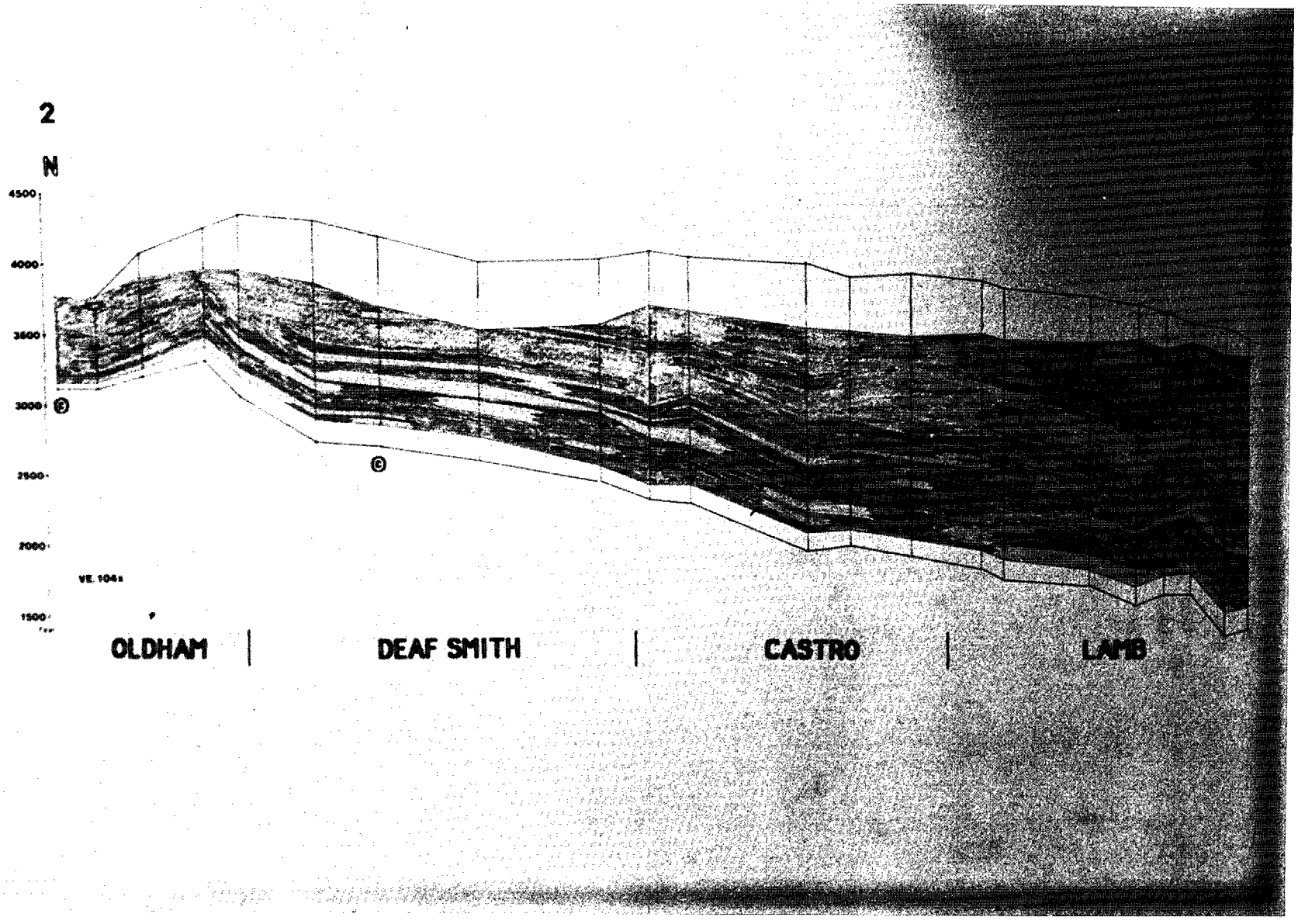
ISOPACH MAP
LOWER PENNSYLVANIAN CLASTICS

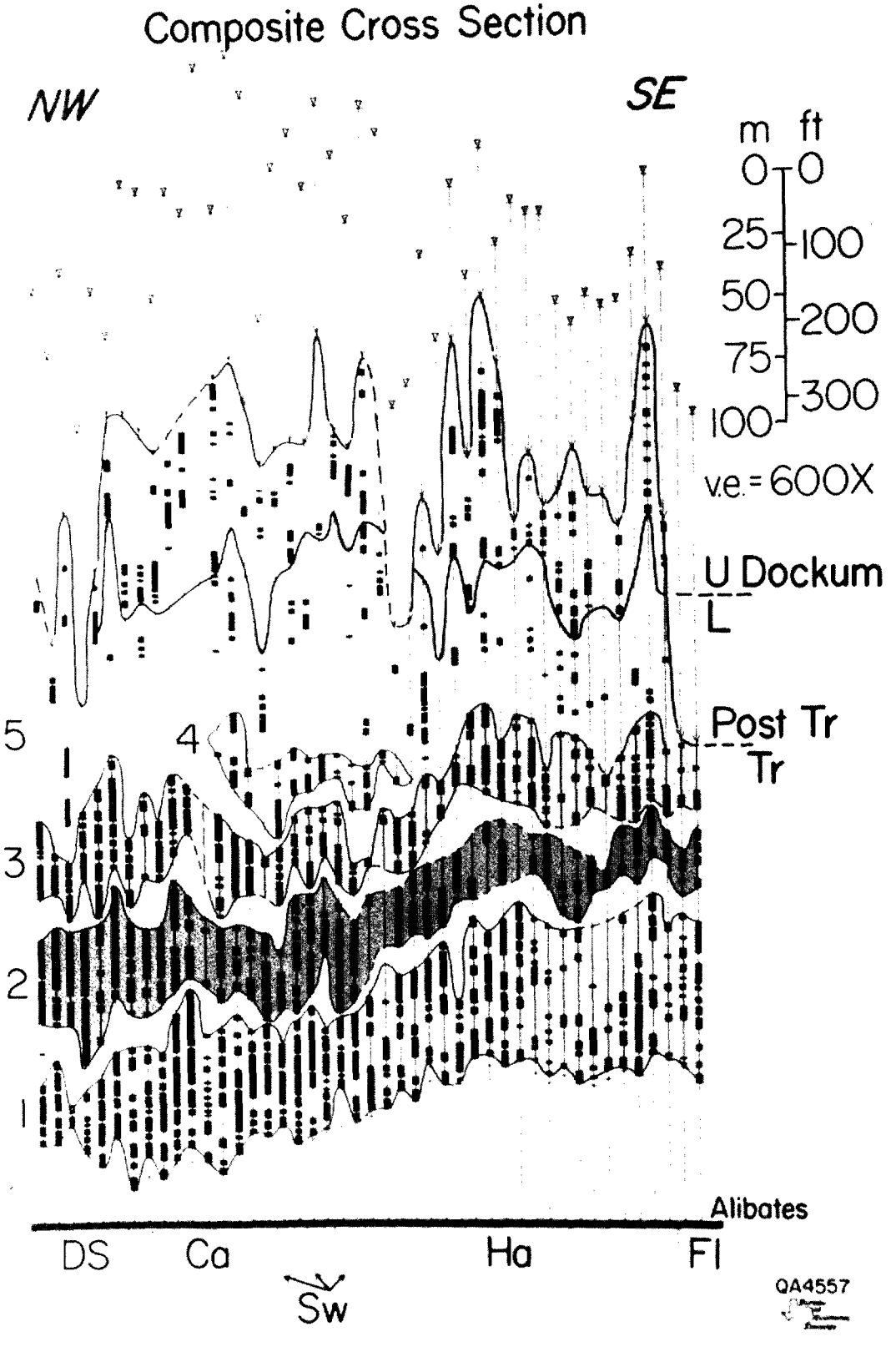


MISSISSIPPIAN SUBCROP
AND BASEMENT STRUCTURE

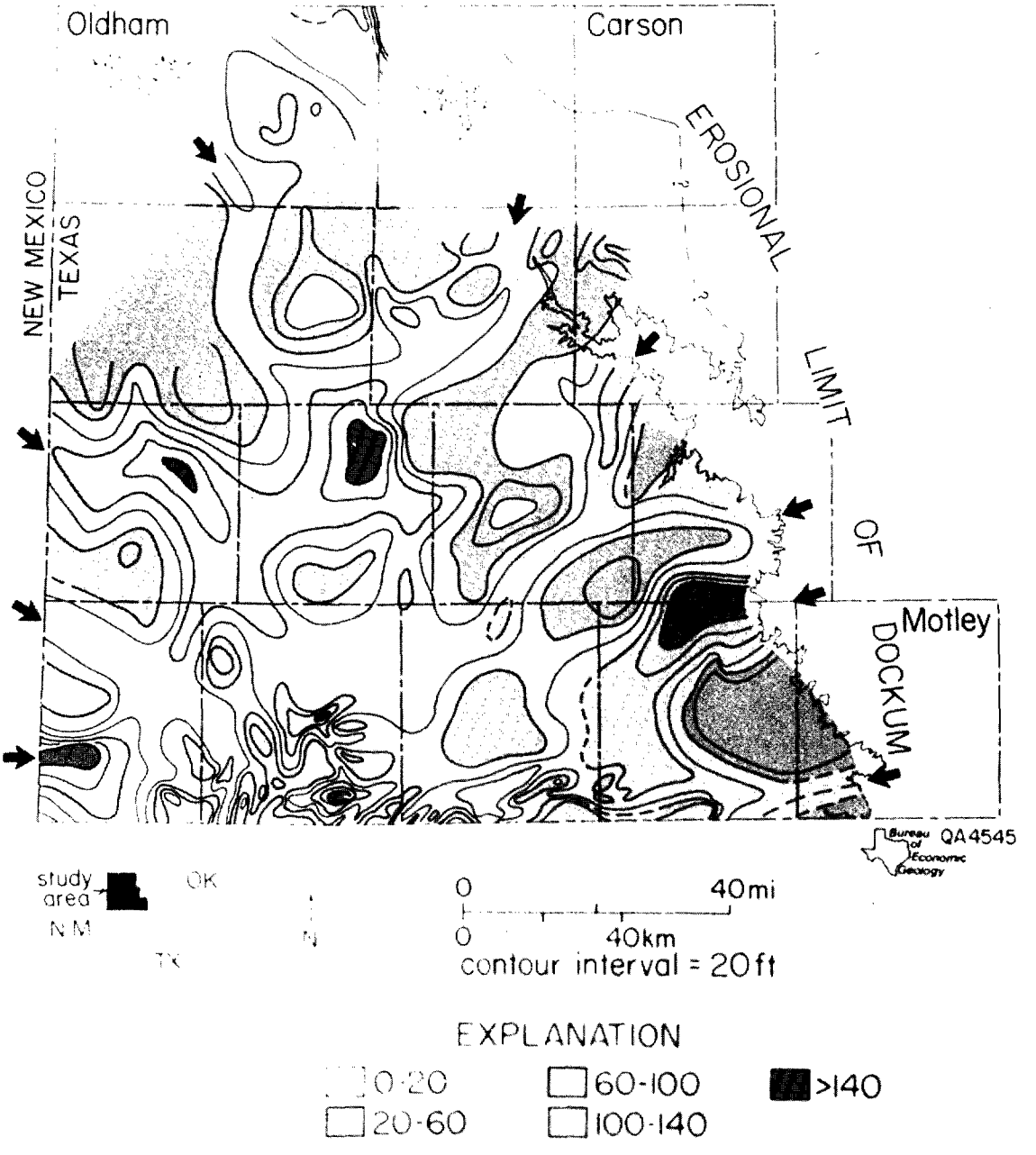
M on Ellenberger
M on basement
IP on basement

QA578

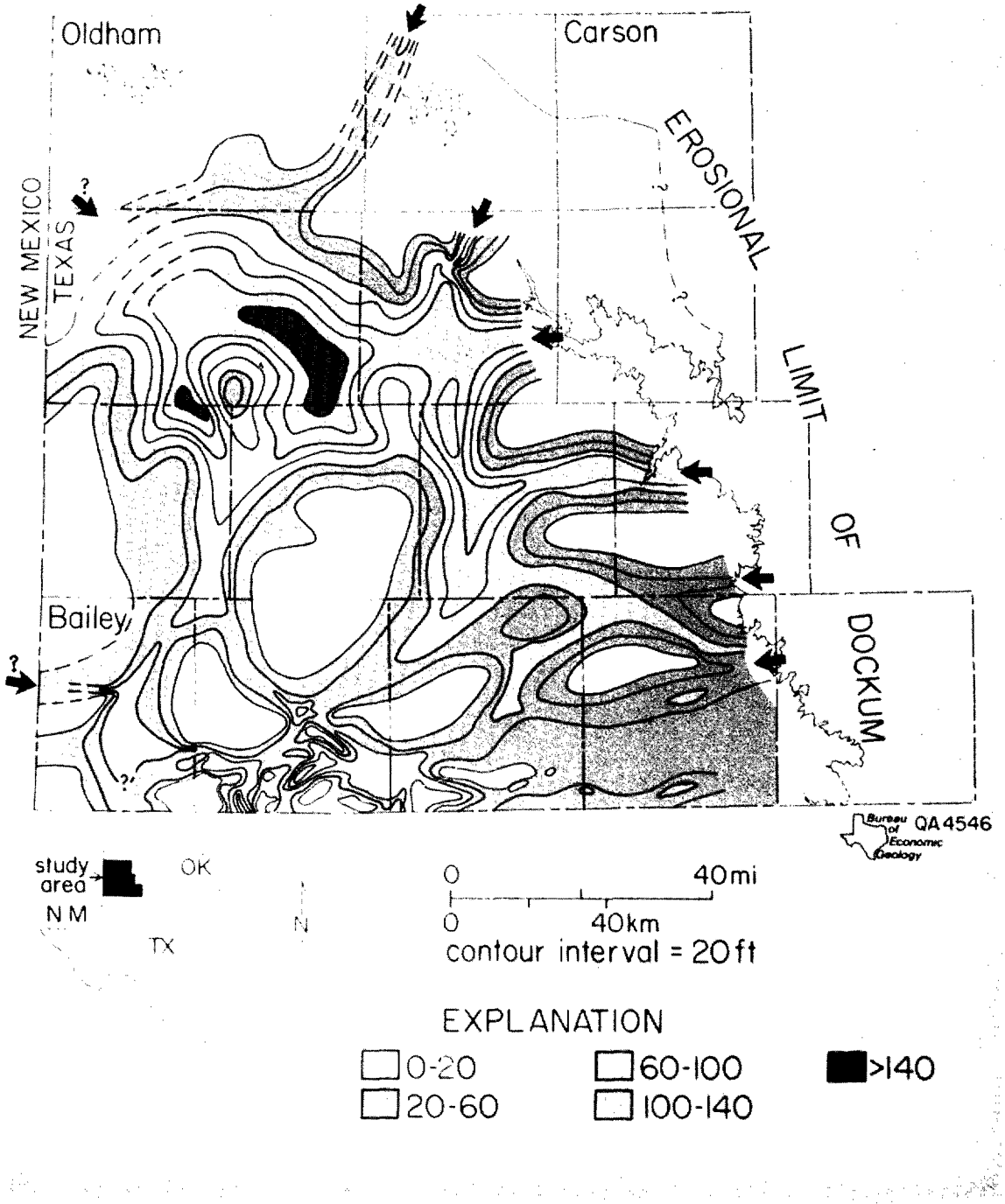

2
N
4500
4000
3500
3000
2500
2000
1500
VE. 104x
OLDHAM
DEAF SMITH
CASTRO
LAMB


Composite Cross Section
NW
SE
m ft
0 0
25 100
50 200
75 300
100 300
v.e. = 600X
U Dockum
L
Post Tr
Tr
5
4
3
2
1
Alibates
DS
Ca
Ha
Fl
Sw
QA4557

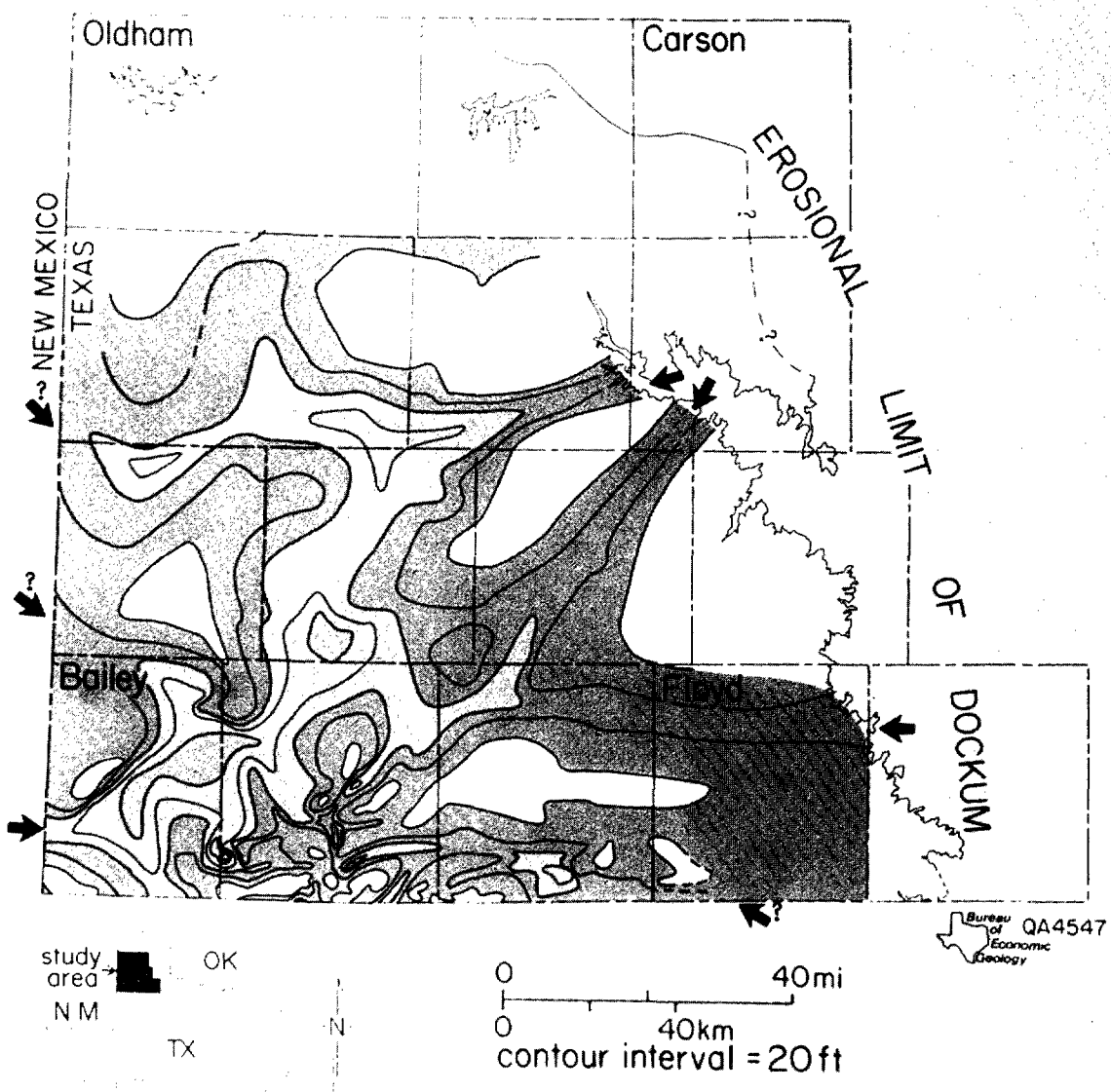
NET SANDSTONE PACKAGE NO.1

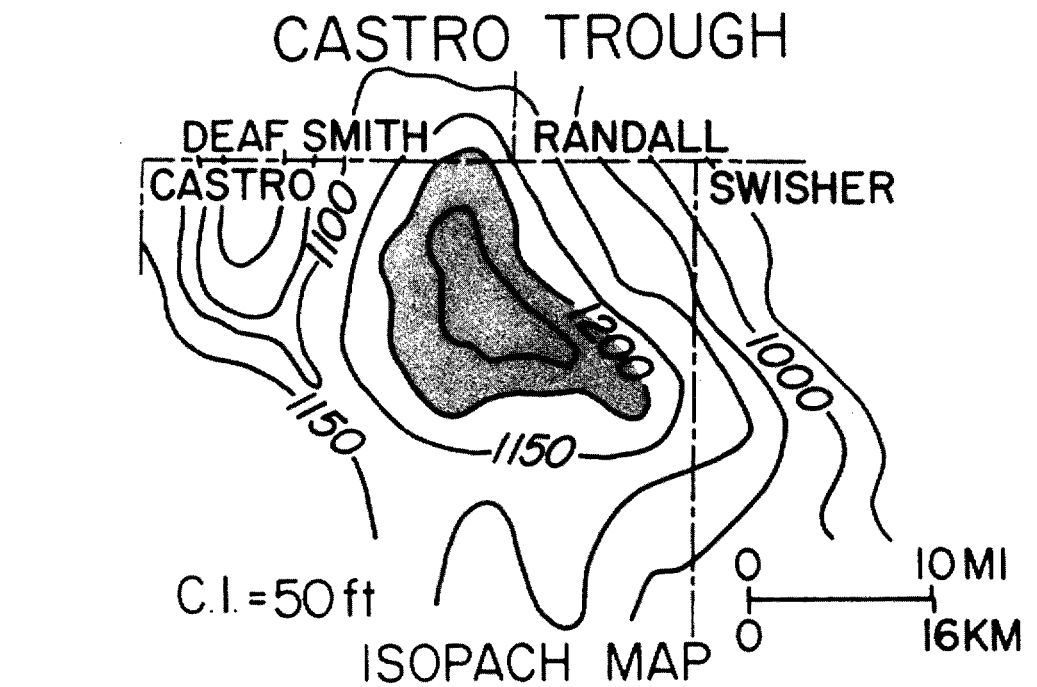


NET SANDSTONE PACKAGE NO.2

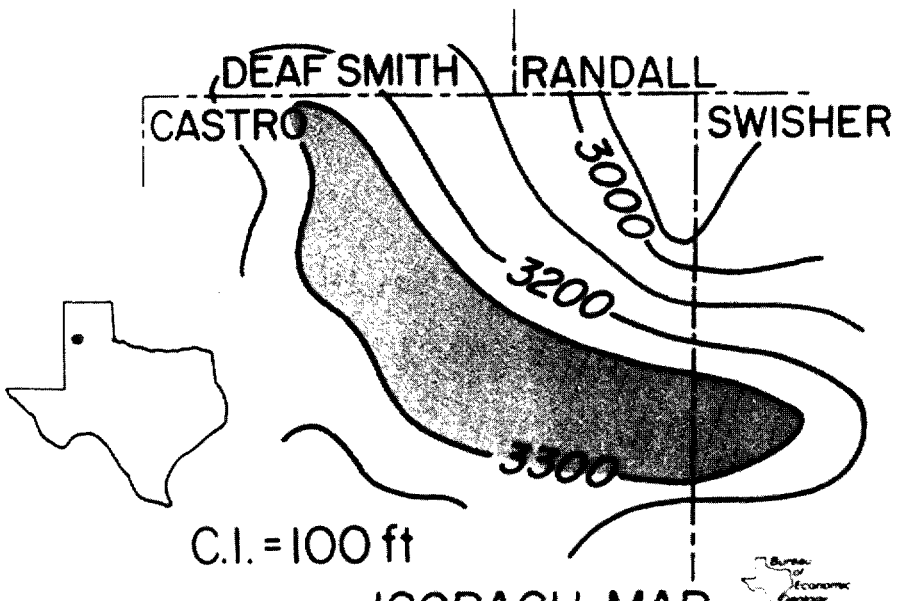


NET SANDSTONE PACKAGE NO.3

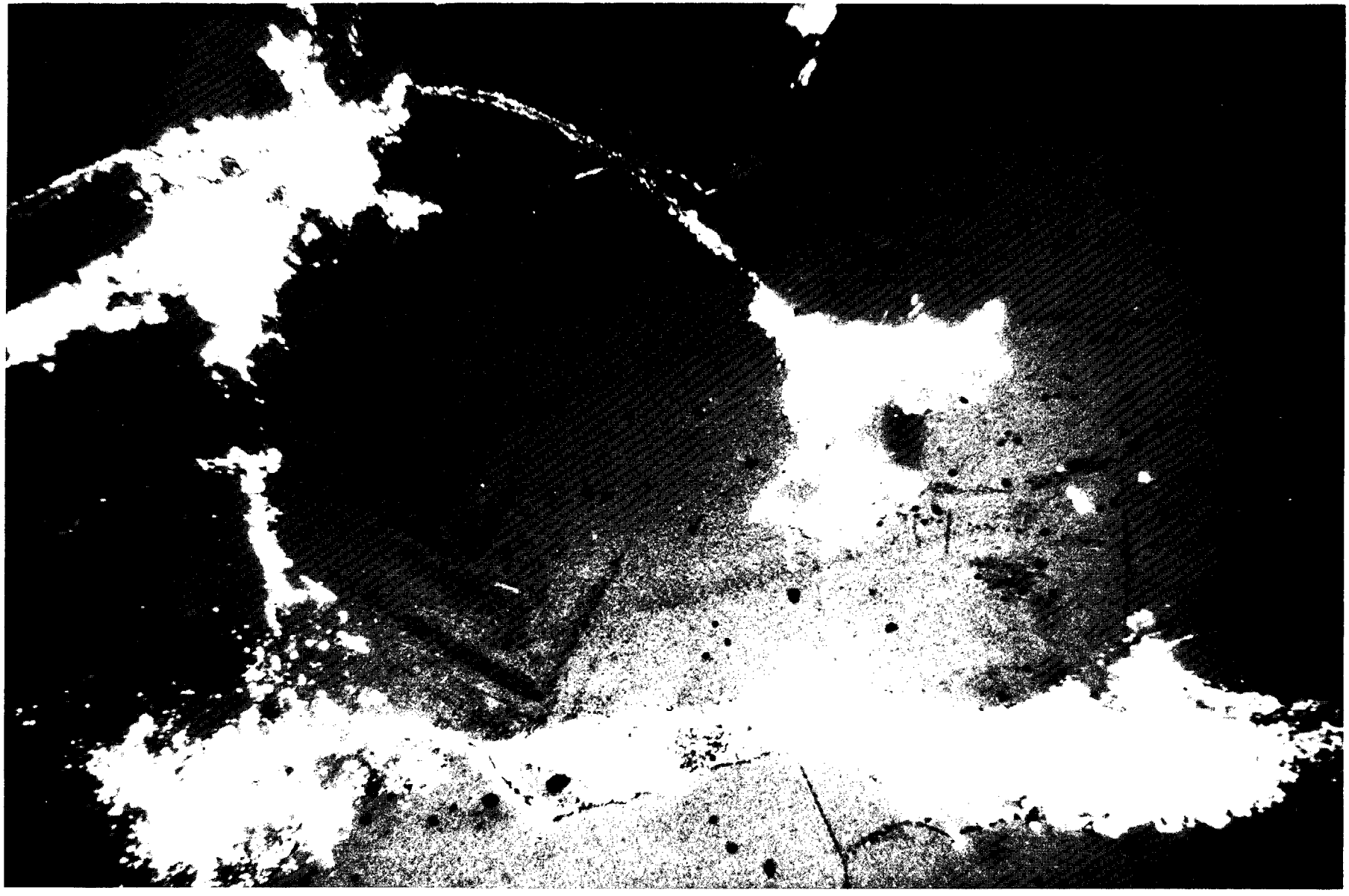


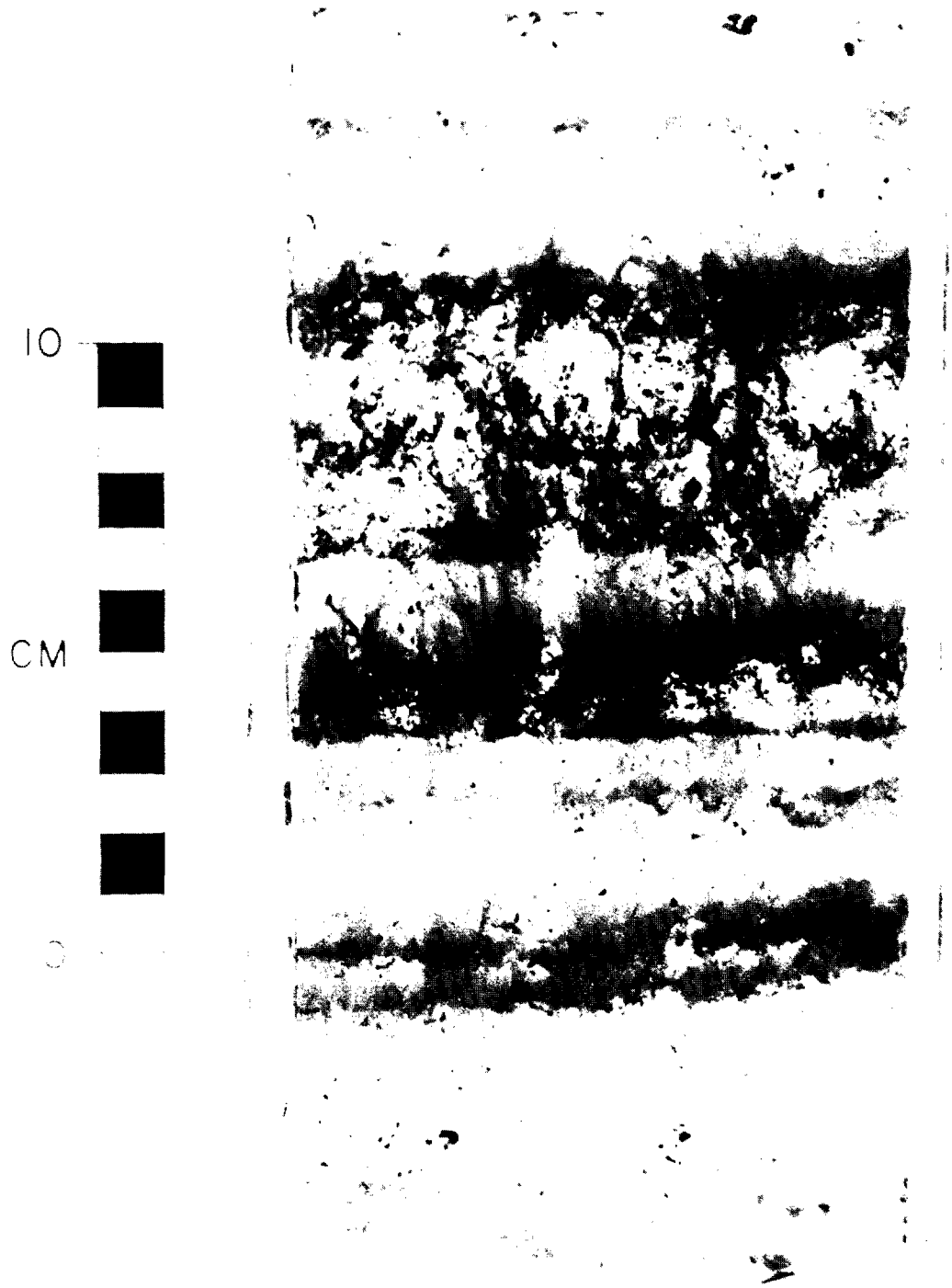


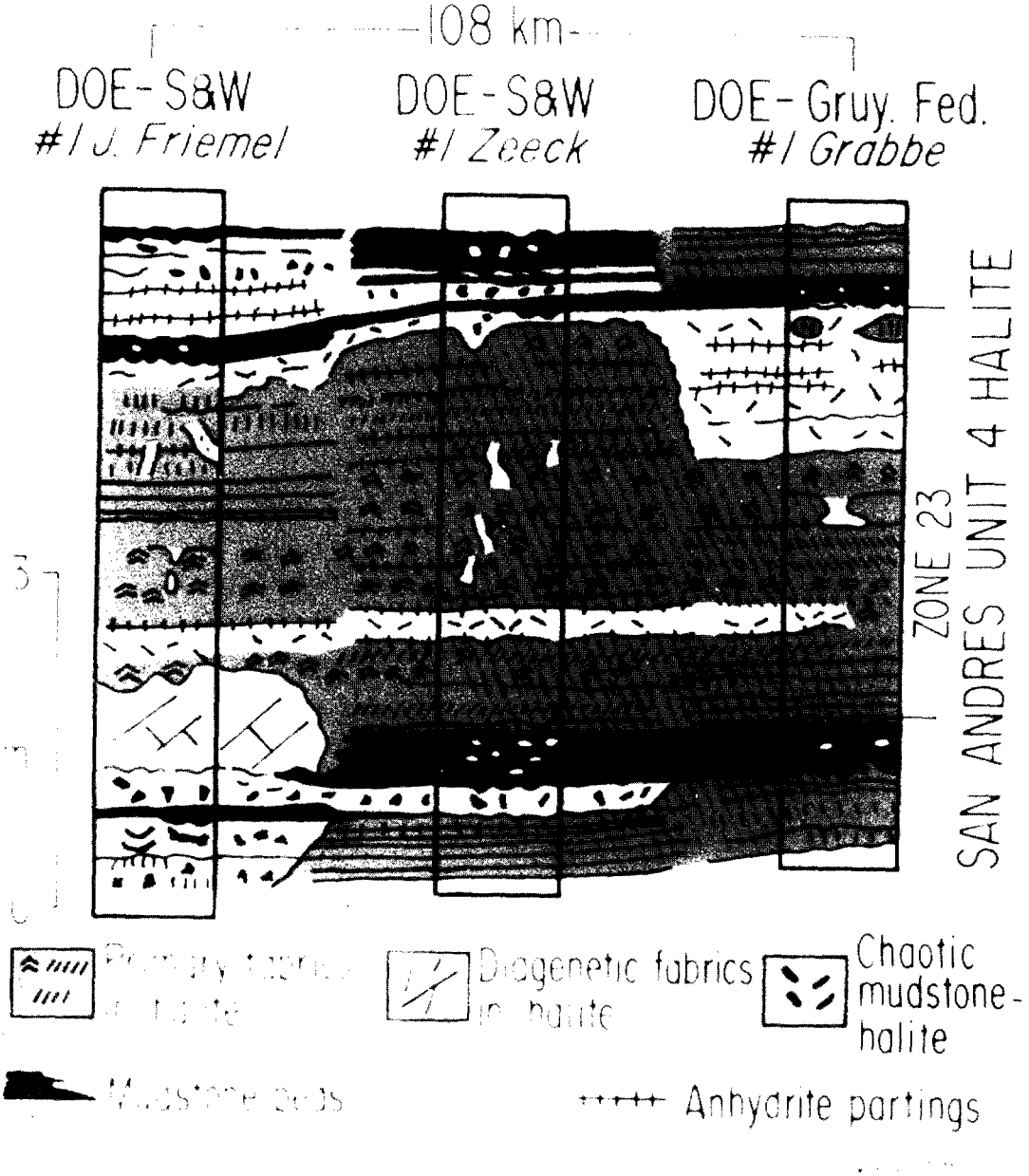
ISOPACH MAP
UPPERMOST PERMIAN - UPPER TRIASSIC
Top of Alibates to base of Ogallala

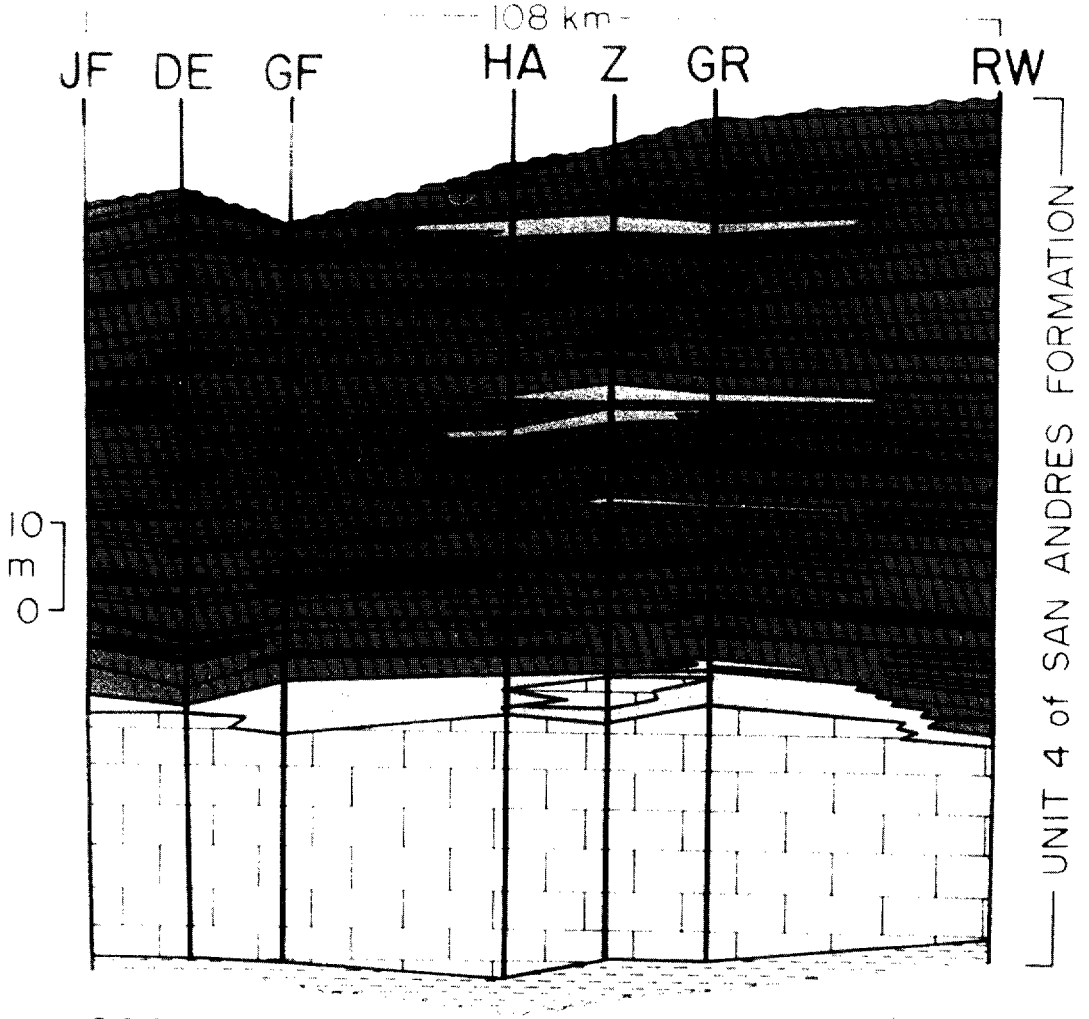


ISOPACH MAP
MIDDLE AND UPPER PERMIAN
Top of Tubb to top of Alibates




10
CM


108 km
DOE-S&W
#1 J. Friemel
DOE-S&W
#1 Zeeck
DOE-Gruy. Fed.
#1 Grabbe
SAN ANDRES UNIT 4 HALITE
ZONE 23
Diagenetic fabrics in halite
Chaotic mudstone-halite
Anhydrite partings



CORED WELLS:

RW = Rex White, **GR** = Grabbe, **Z** = Zeeck, **HA** = Harman, **GF** = G. Friemel, **DE** = Detten, **JF** = J. Friemel

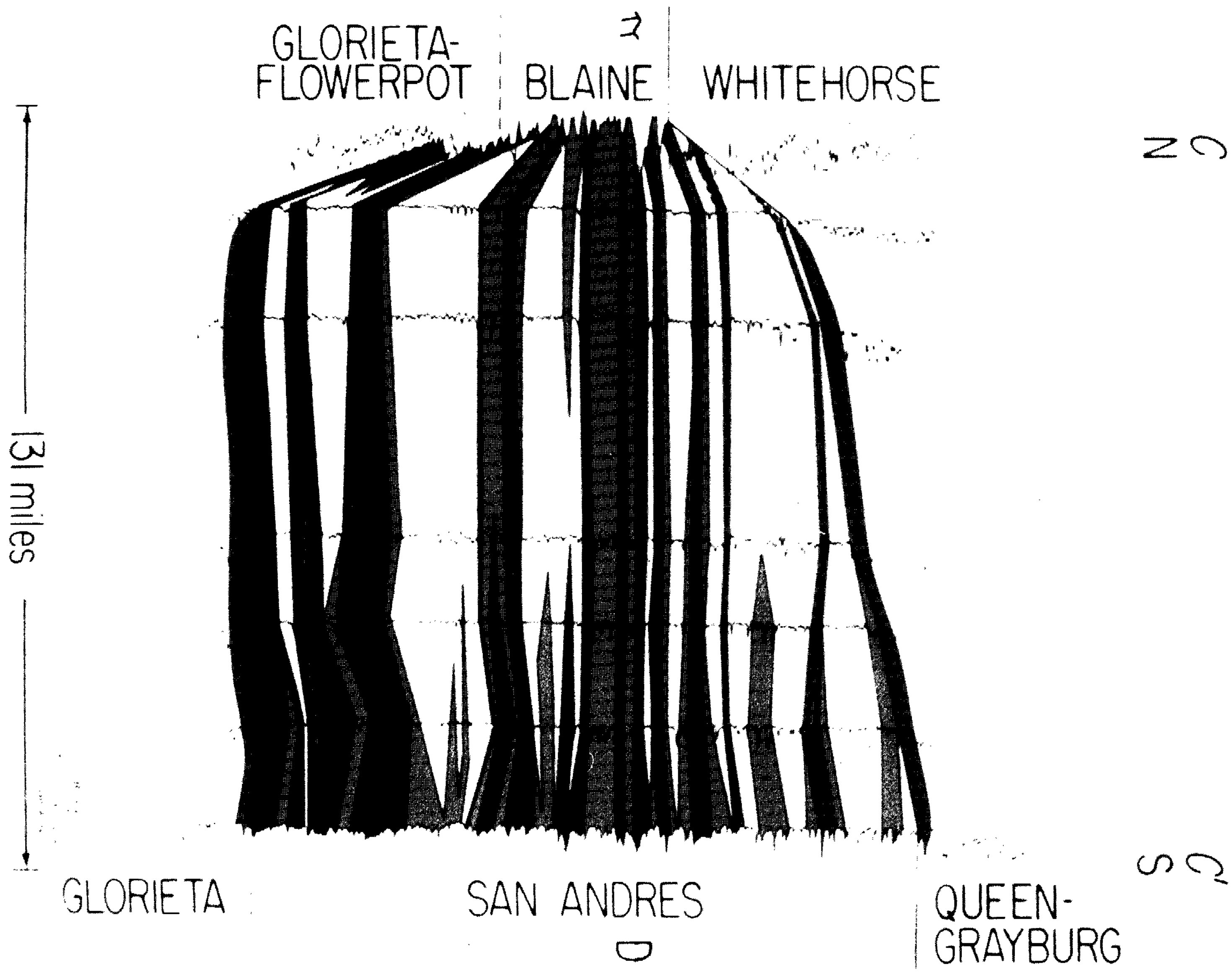
Anhydritic halite

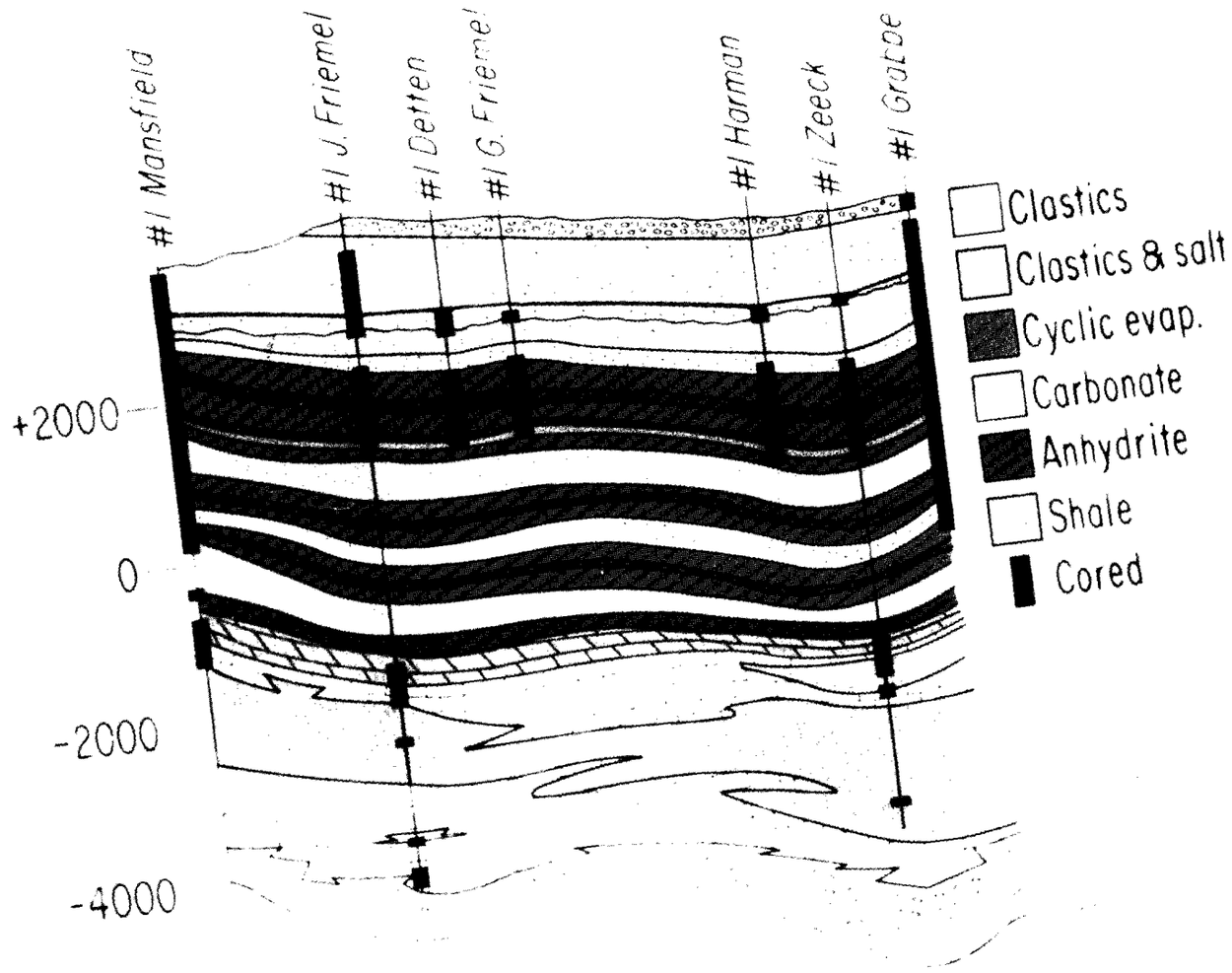
Muddy halite

Mudstone

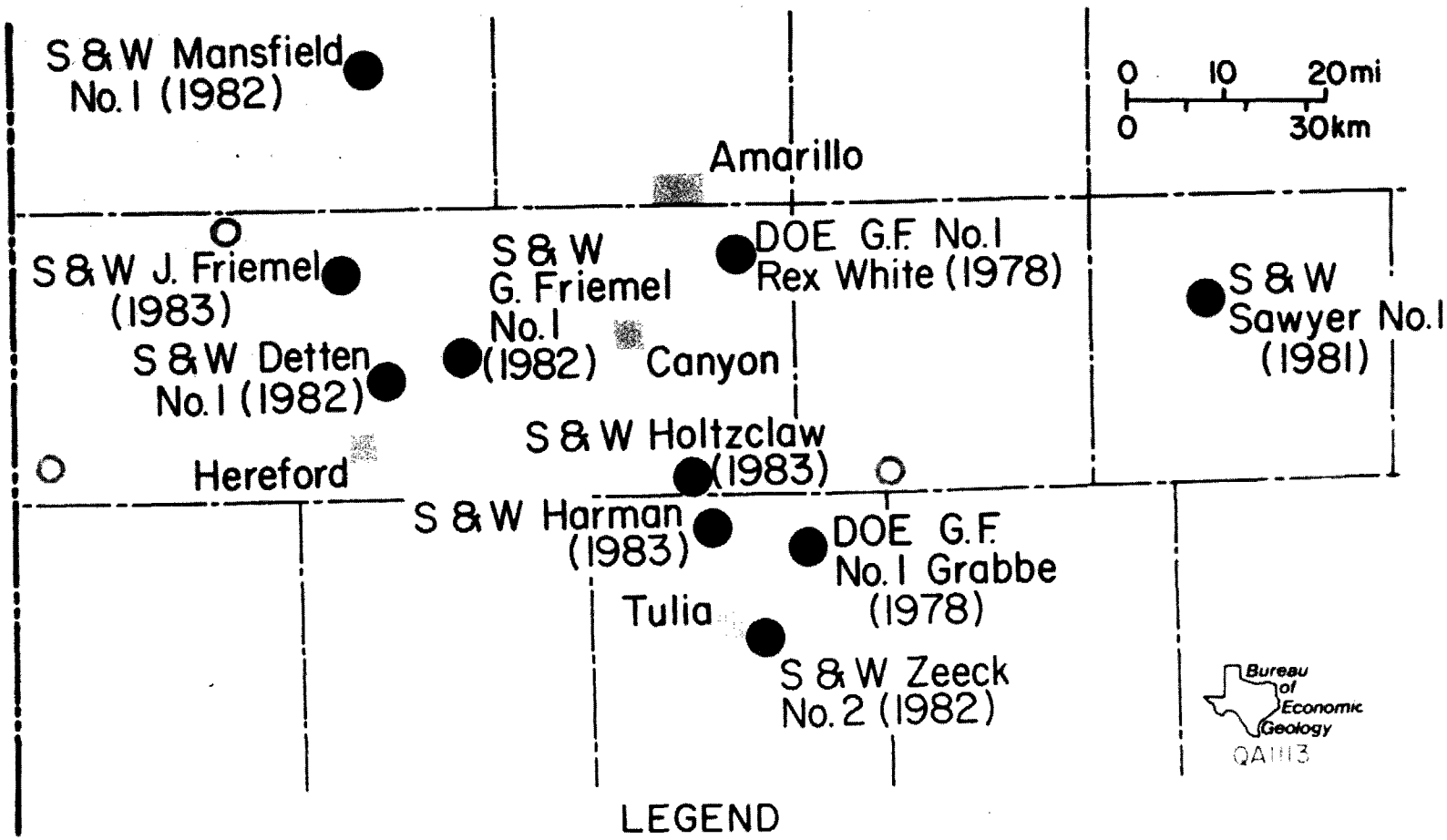
Anhydrite

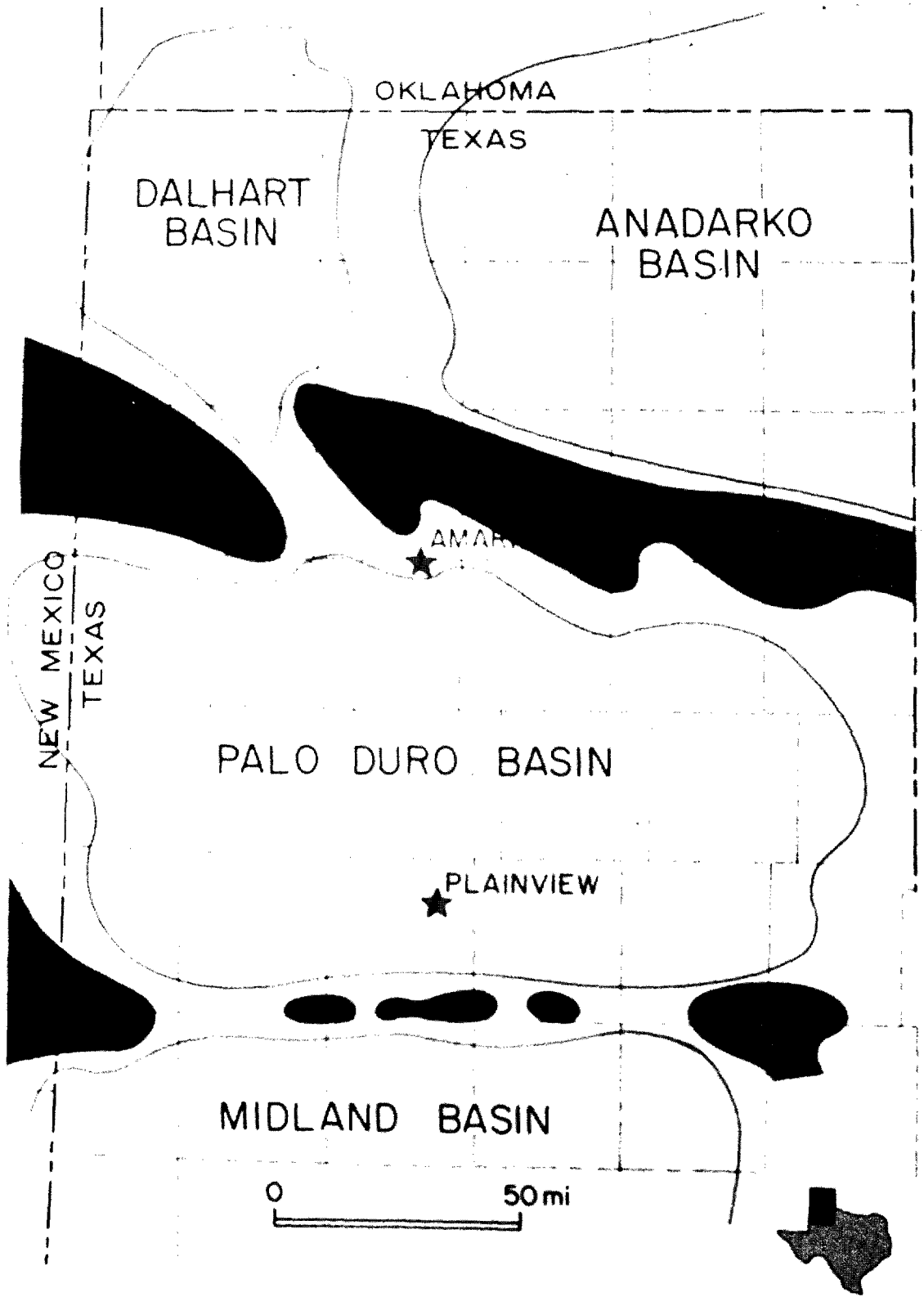
Carbonate


GLORIETA-
FLOWERPOT
BLAINE
WHITEHORSE
C
N
131 miles
GLORIETA
SAN ANDRES
D
QUEEN-
GRAYBURG
C'
S

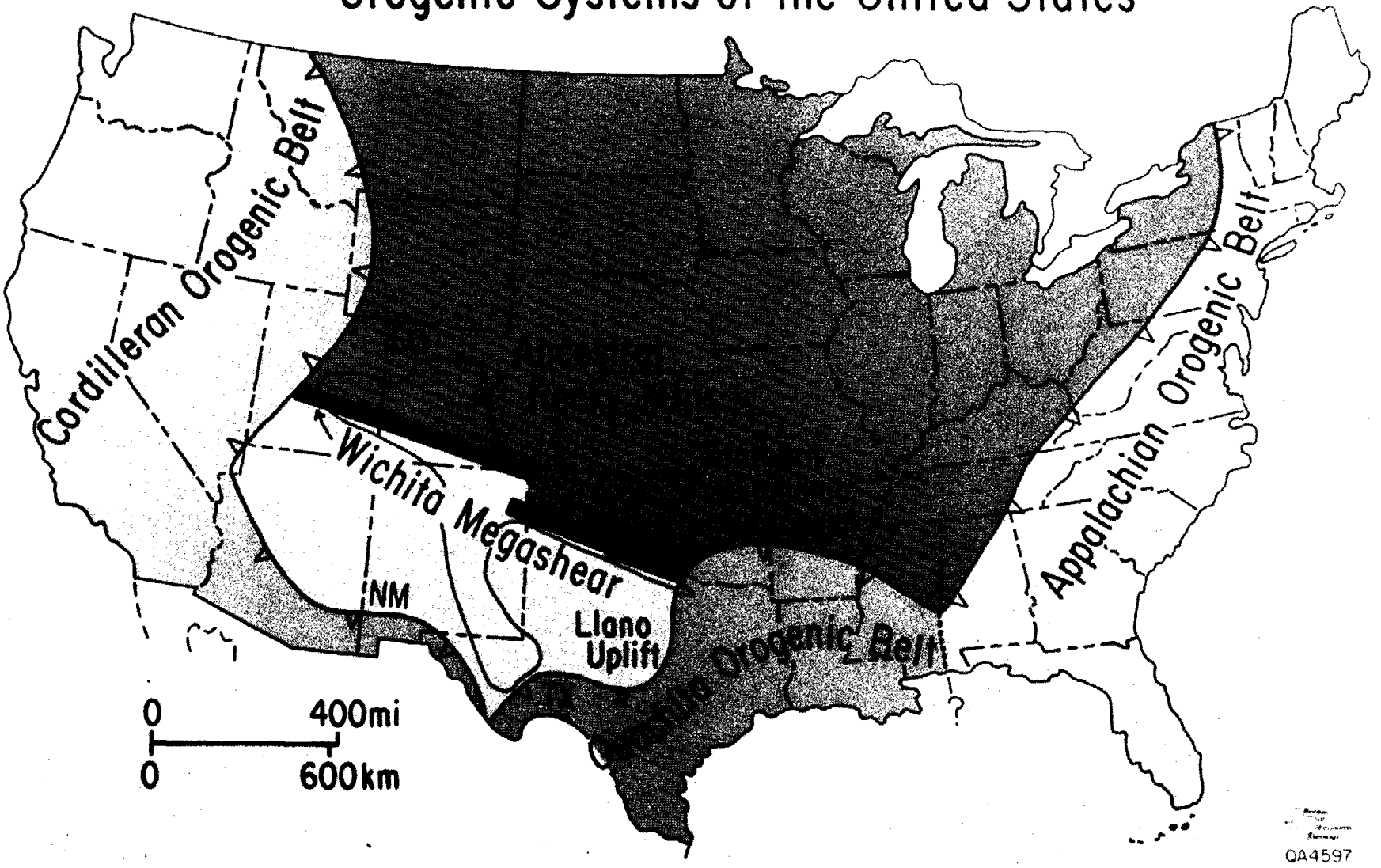

#1 Mansfield
#1 J. Friemel
#1 Detten
#1 G. Friemel
#1 Harman
#1 Zeeck
#1 Grotge
+2000
0
-2000
-4000
Clastics
Clastics & salt
Cyclic evap.
Carbonate
Anhydrite
Shale
Cored

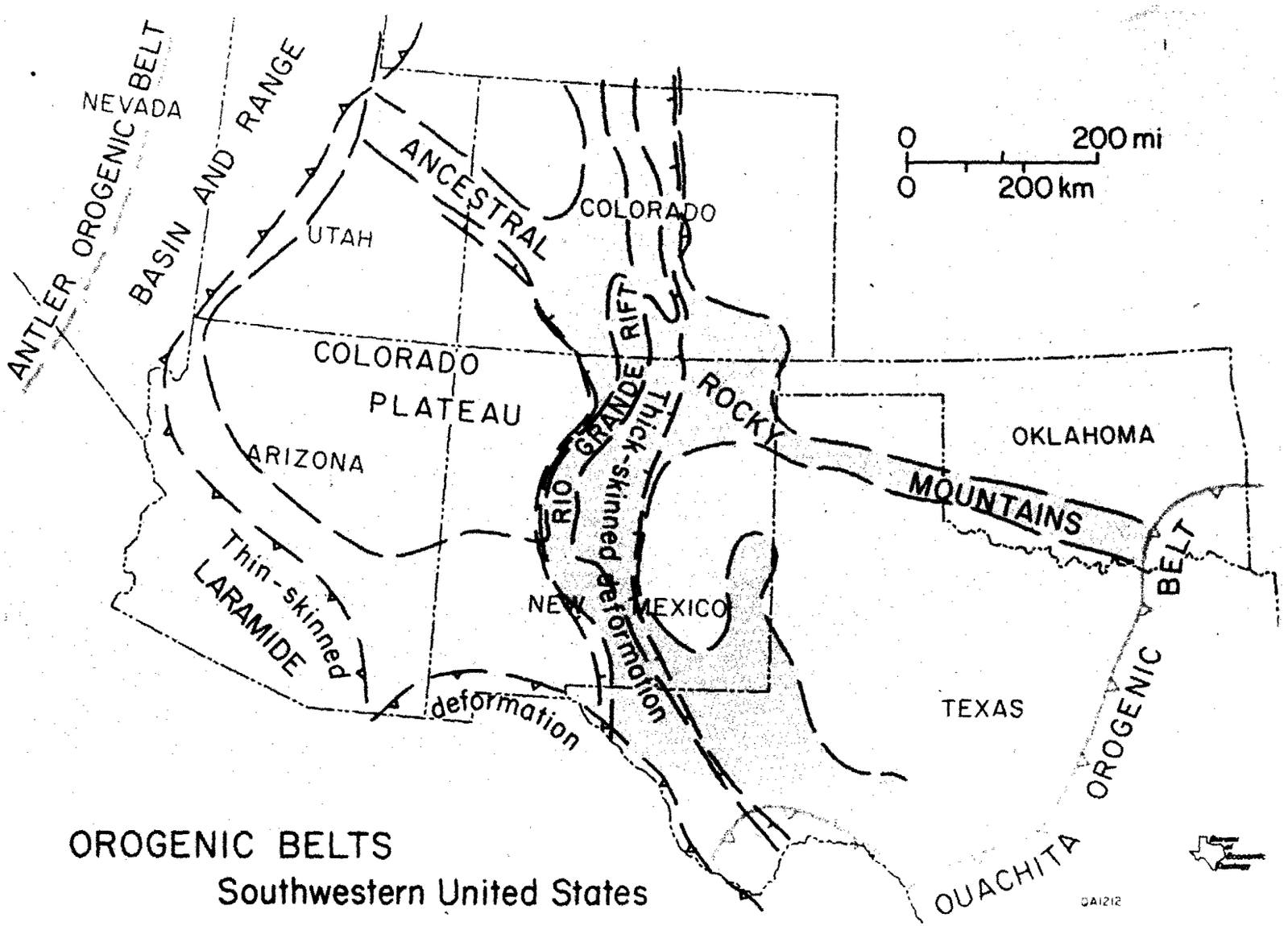
NWTS TEST WELLS




OKLAHOMA
TEXAS
DALHART
BASIN
ANADARKO
BASIN
AMAR
NEW MEXICO
TEXAS
PALO DURO BASIN
PLAINVIEW
MIDLAND BASIN
0
50 mi

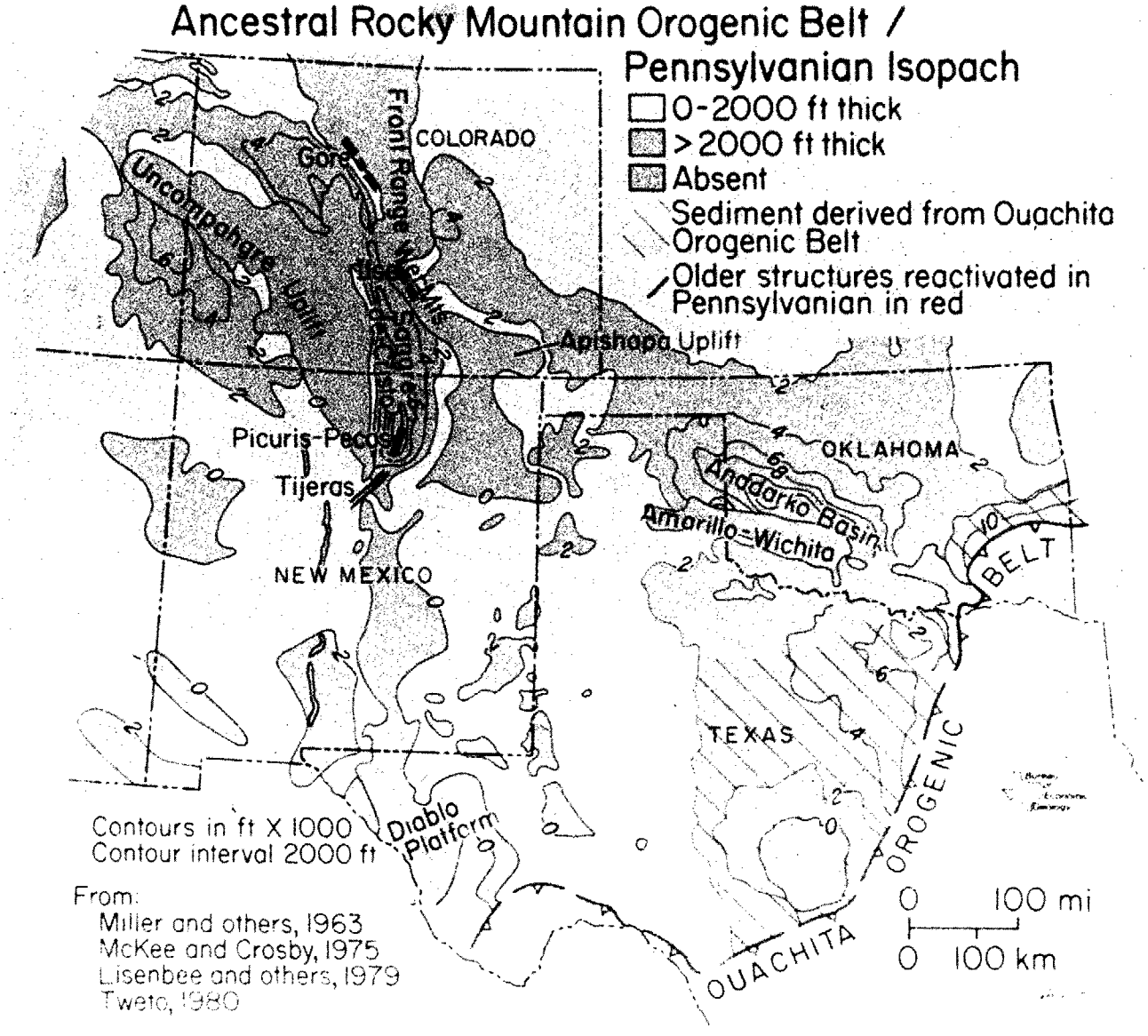
Orogenic Systems of the United States

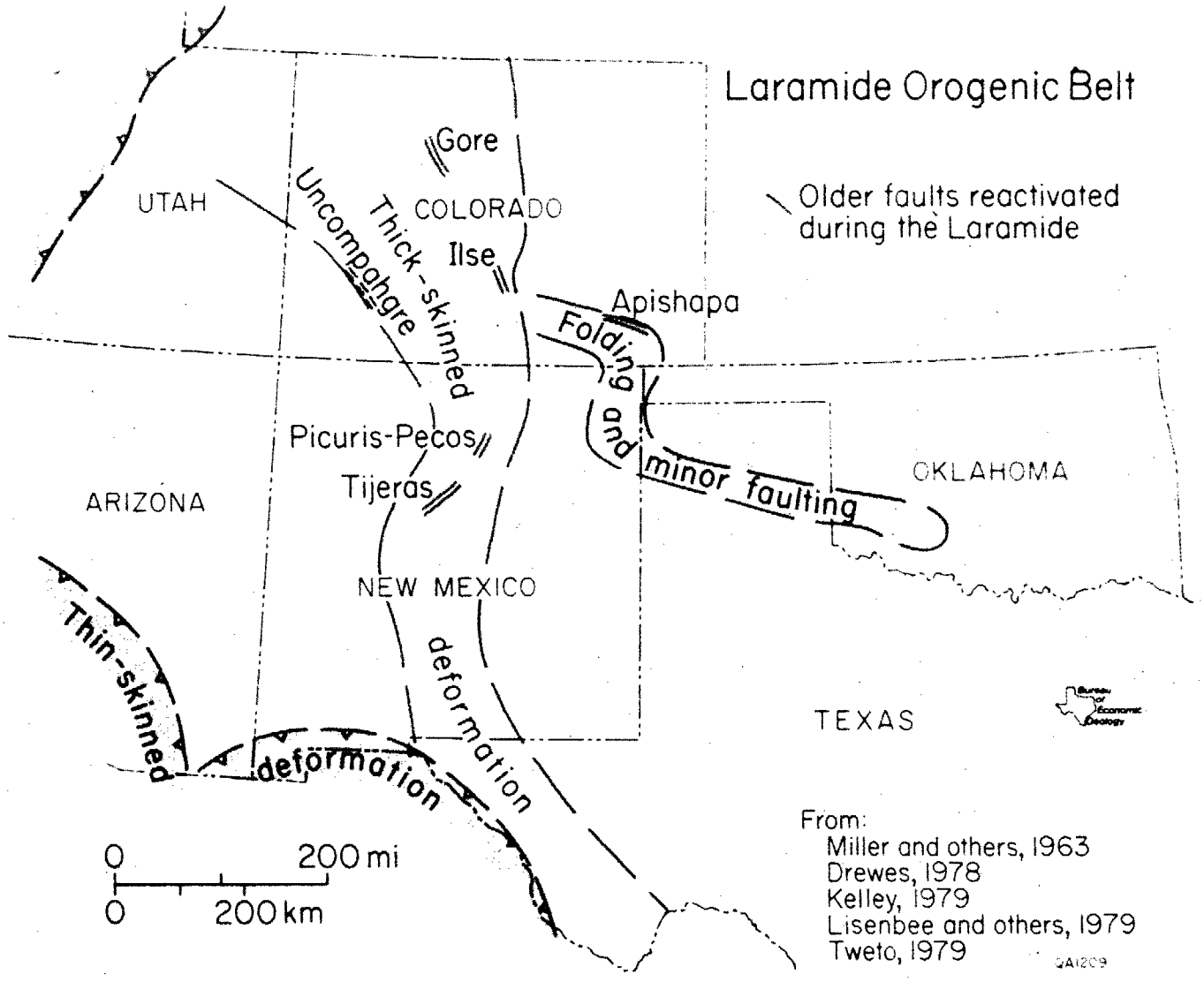




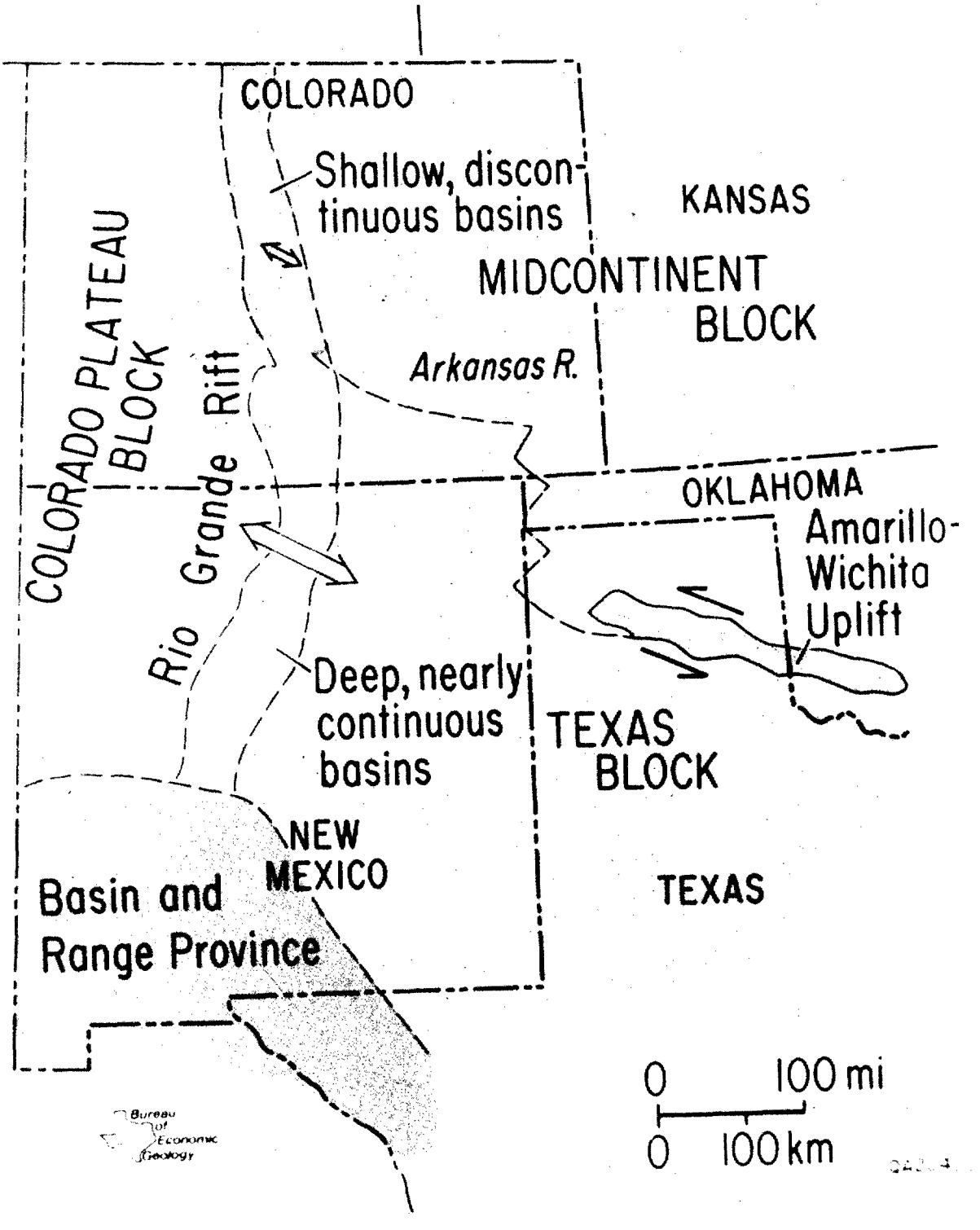
OROGENIC BELTS

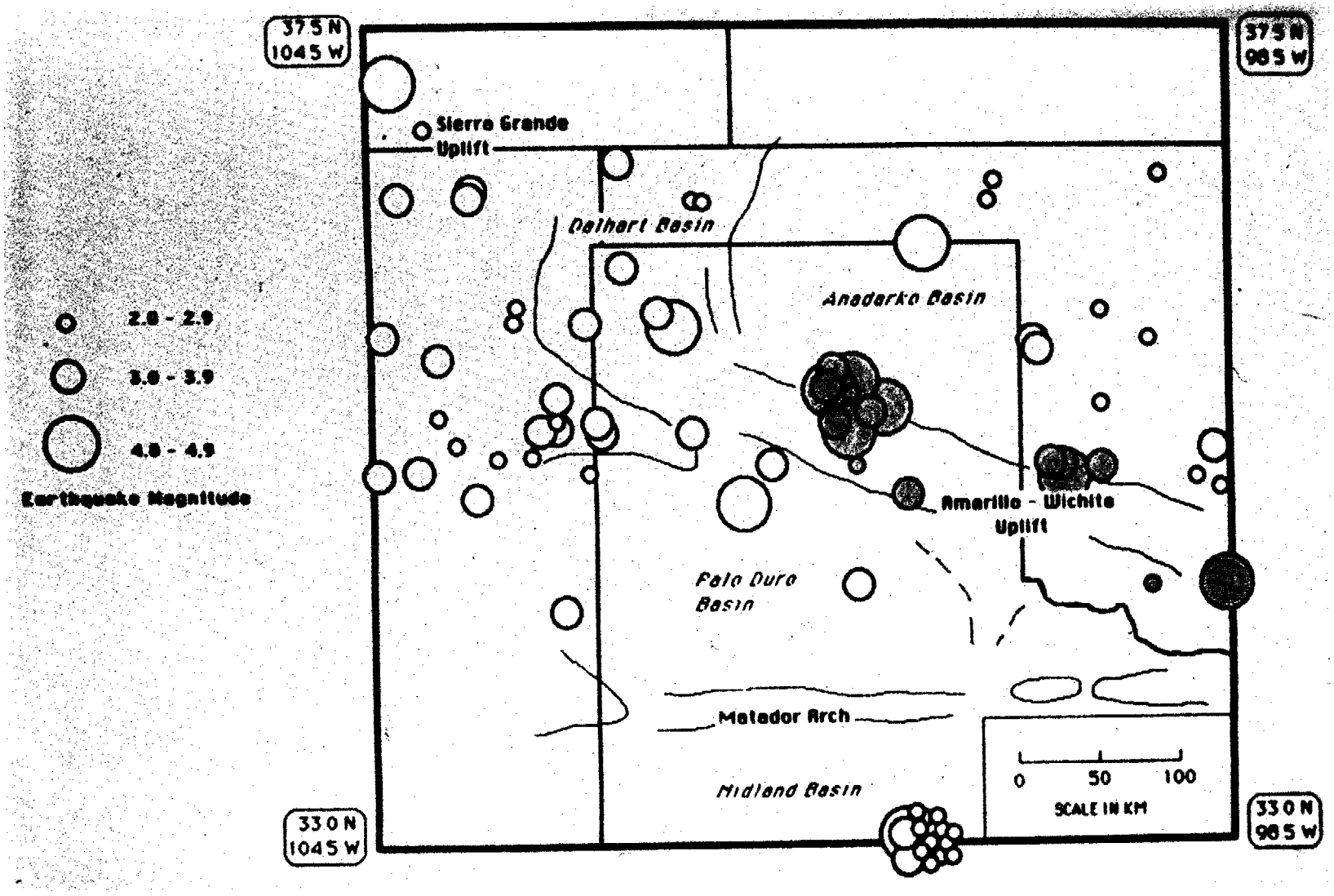
Southwestern United States


Ancestral Rocky Mountain Orogenic Belt /
Pennsylvanian Isopach
0-2000 ft thick
>2000 ft thick
Absent
Sediment derived from Ouachita Orogenic Belt
Older structures reactivated in Pennsylvanian in red
COLORADO
Gore
Uncompahgre Uplift
Front Range
Apishapa Uplift
Picuris-Pecos
Tijeras
NEW MEXICO
OKLAHOMA
Anadarko Basin
Amarillo-Wichita
BELT
TEXAS
OROGENIC
Diablo Platform
OUACHITA
Contours in ft X 1000
Contour interval 2000 ft
From:
Miller and others, 1963
McKee and Crosby, 1975
Lisenbee and others, 1979
Tweto, 1980
0 100 mi
0 100 km

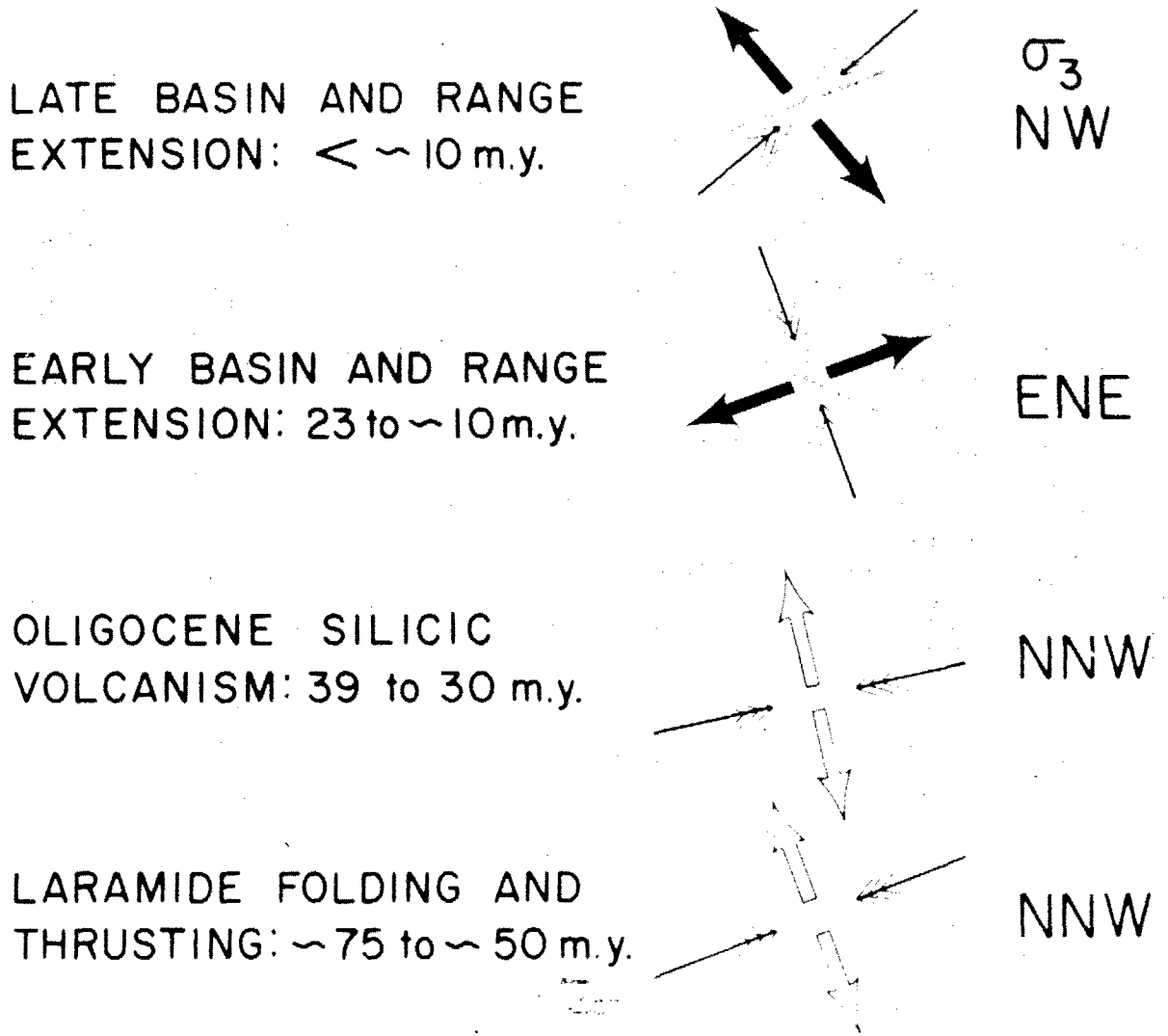

Laramide Orogenic Belt
Older faults reactivated during the Laramide
Gore
Uncompahgre
Thick-skinned
Ilse
Apishapa
Folding and minor faulting
Picuris-Pecos
Tijeras
UTAH
COLORADO
ARIZONA
NEW MEXICO
OKLAHOMA
TEXAS
Thin-skinned deformation
deformation
0 200 mi
0 200 km
From:
Miller and others, 1963
Drewes, 1978
Kelley, 1979
Lisenbee and others, 1979
Tweto, 1979

NEOGENE TECTONIC SETTING

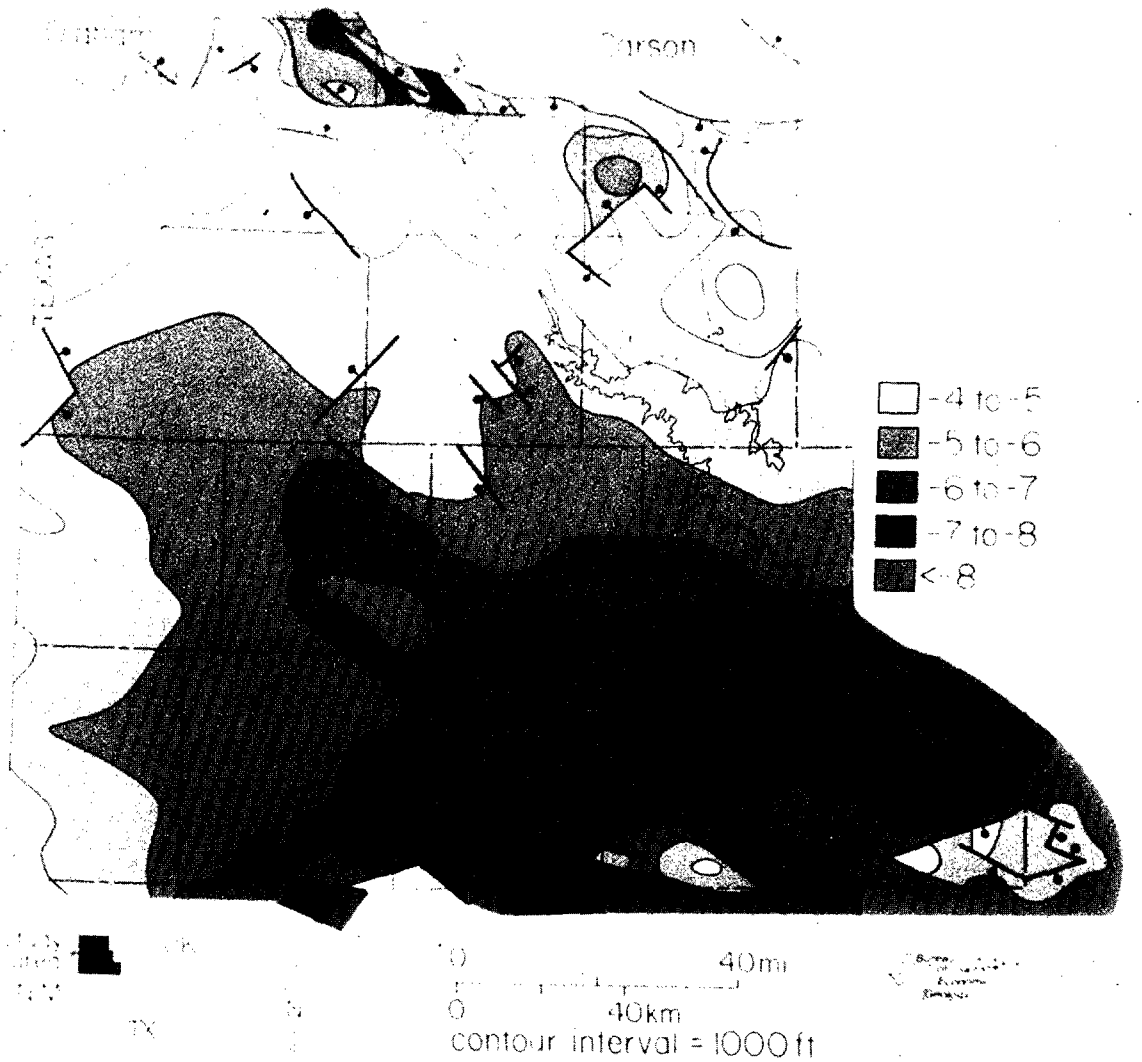



37.5 N
104.5 W
37.5 N
98.5 W
Sierra Grande
Uplift
Dalhart Basin
Anadarko Basin
Amarillo - Wichita
Uplift
Palo Duro
Basin
Matador Arch
Midland Basin
0
50
100
SCALE IN KM
33.0 N
104.5 W
33.0 N
98.5 W
2.8 - 2.9
3.8 - 3.9
4.8 - 4.9
Earthquake Magnitude

SANGRE DE CRISTO UPLIFT
SIERRA GRANDE ARCH
OKLAHOMA
WICHITA
SYSTEM
SACRAMENTO UPLIFT
DIABLO PLATFORM
OUACHITA
TECTONIC
BELT
100mi


LATE BASIN AND RANGE
EXTENSION: < ~ 10 m.y.
σ3
NW
EARLY BASIN AND RANGE
EXTENSION: 23 to ~ 10 m.y.
ENE
OLIGOCENE SILICIC
VOLCANISM: 39 to 30 m.y.
NNW
LARAMIDE FOLDING AND
THRUSTING: ~ 75 to ~ 50 m.y.
NNW

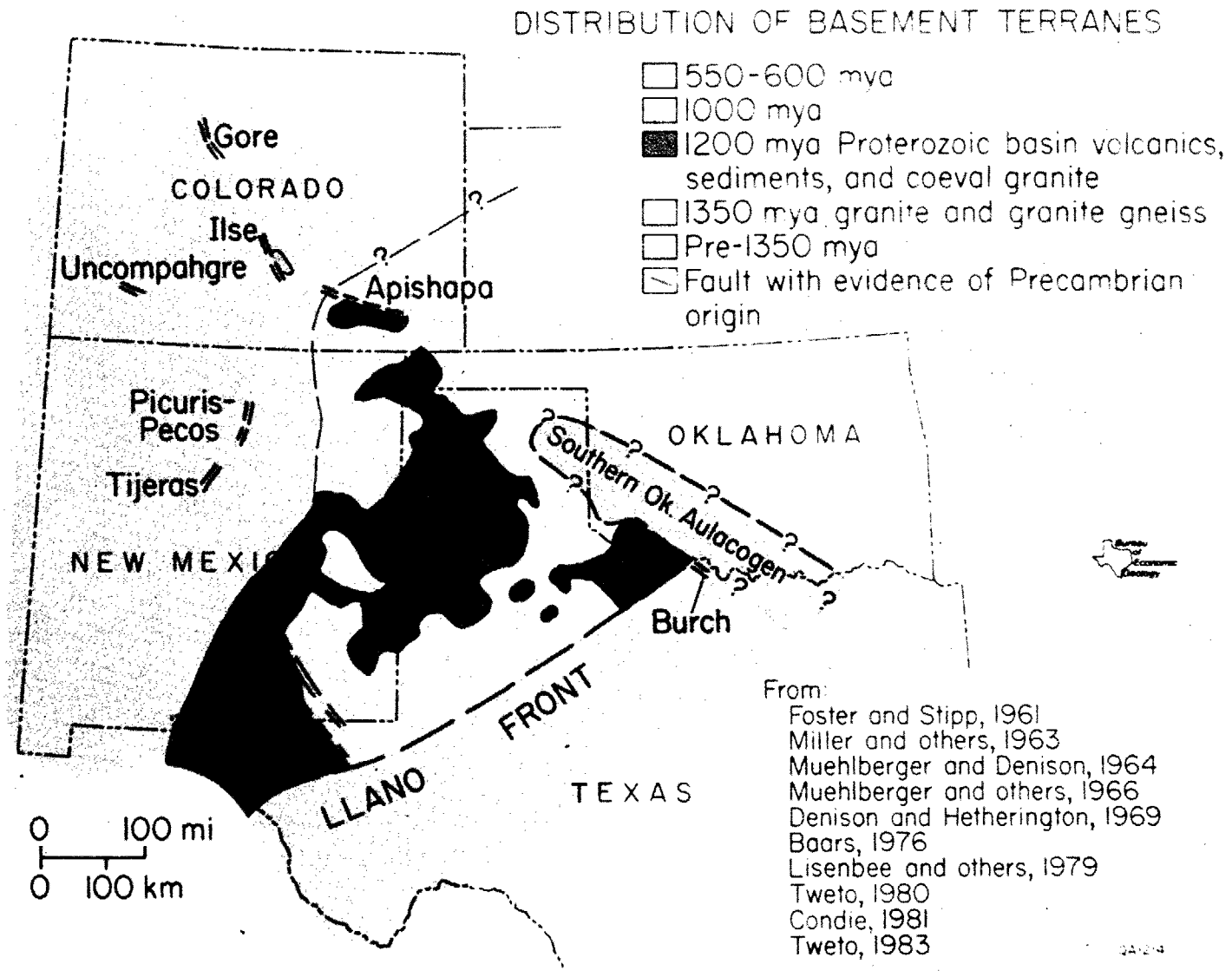
SIMPLIFIED BASEMENT STRUCTURE



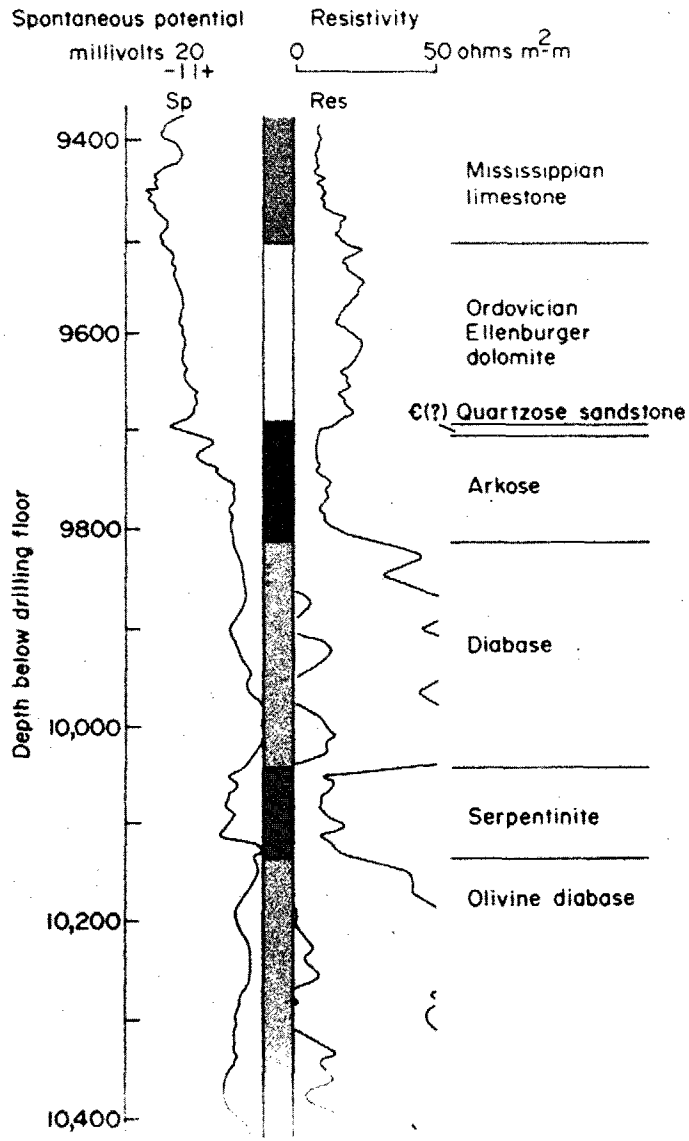
EXPLANATION (ft X 1000)

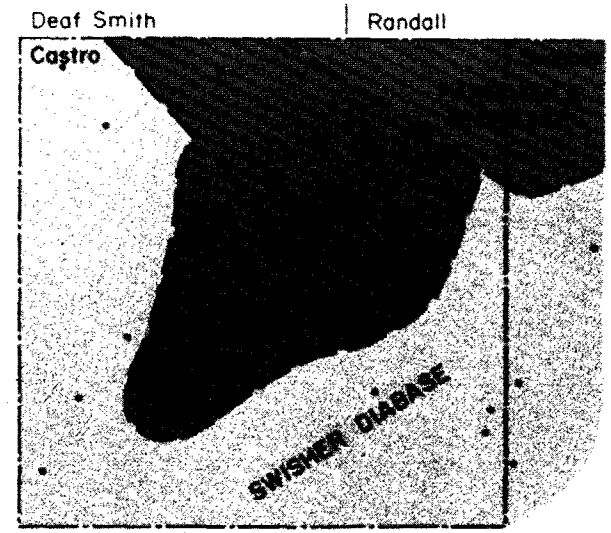
(from Budnik, 1984)

- >1
- 1 to 0
- 0 to -1
- -1 to -2
- -2 to -3
- -3 to -4


DISTRIBUTION OF BASEMENT TERRANES
550-600 mya
1000 mya
1200 mya Proterozoic basin volcanics, sediments, and coeval granite
1350 mya granite and granite gneiss
Pre-1350 mya
Fault with evidence of Precambrian origin
Gore
COLORADO
Ilse
Uncompahgre
Apishapa
Picuris-Pecos
Tijeras
NEW MEXI
OKLAHOMA
Southern Ok. Aulacogen
Burch
FRONT
LLANO
TEXAS
0 100 mi
0 100 km
From:
Foster and Stipp, 1961
Miller and others, 1963
Muehlberger and Denison, 1964
Muehlberger and others, 1966
Denison and Hetherington, 1969
Baars, 1976
Lisenbee and others, 1979
Tweto, 1980
Condie, 1981
Tweto, 1983

SUN OIL COMPANY #1 *Herring*, Castro County



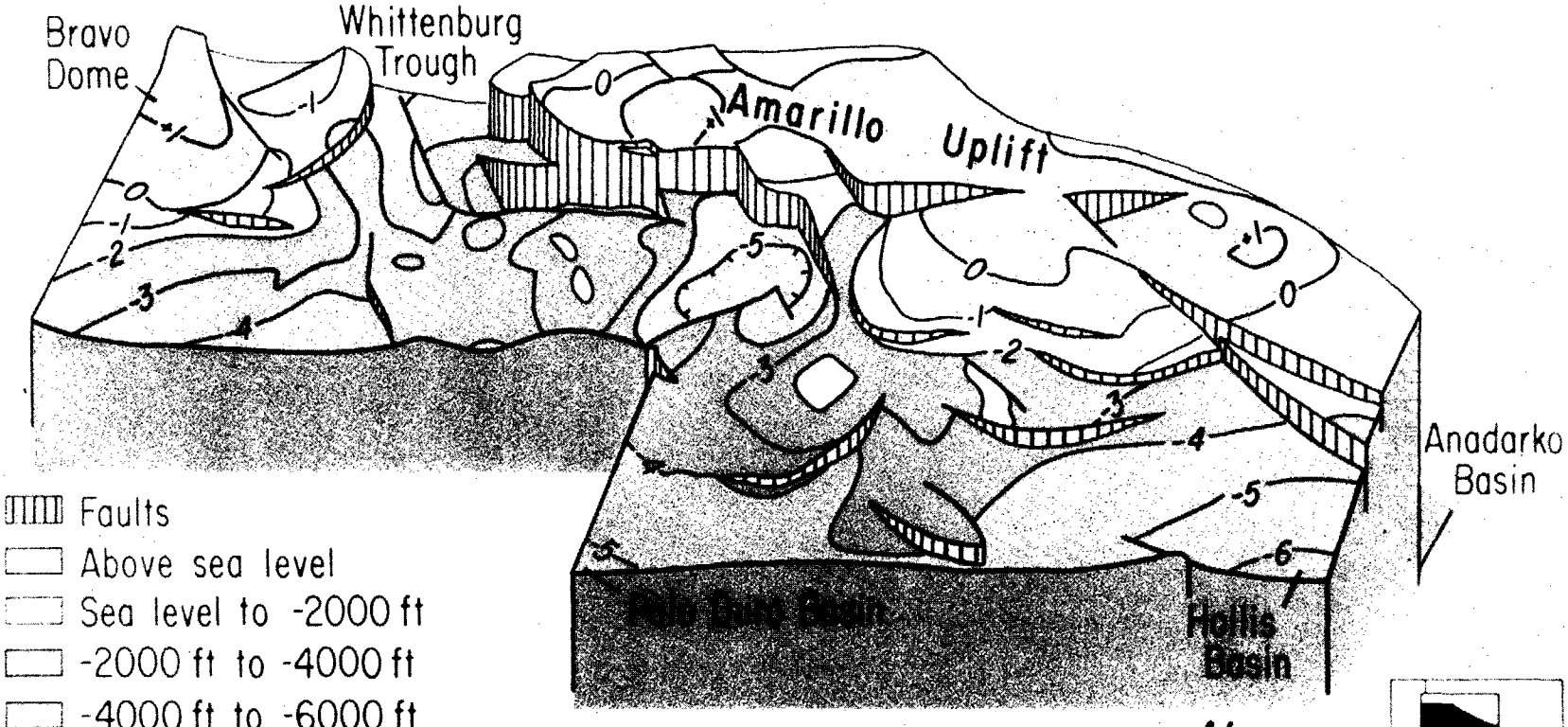


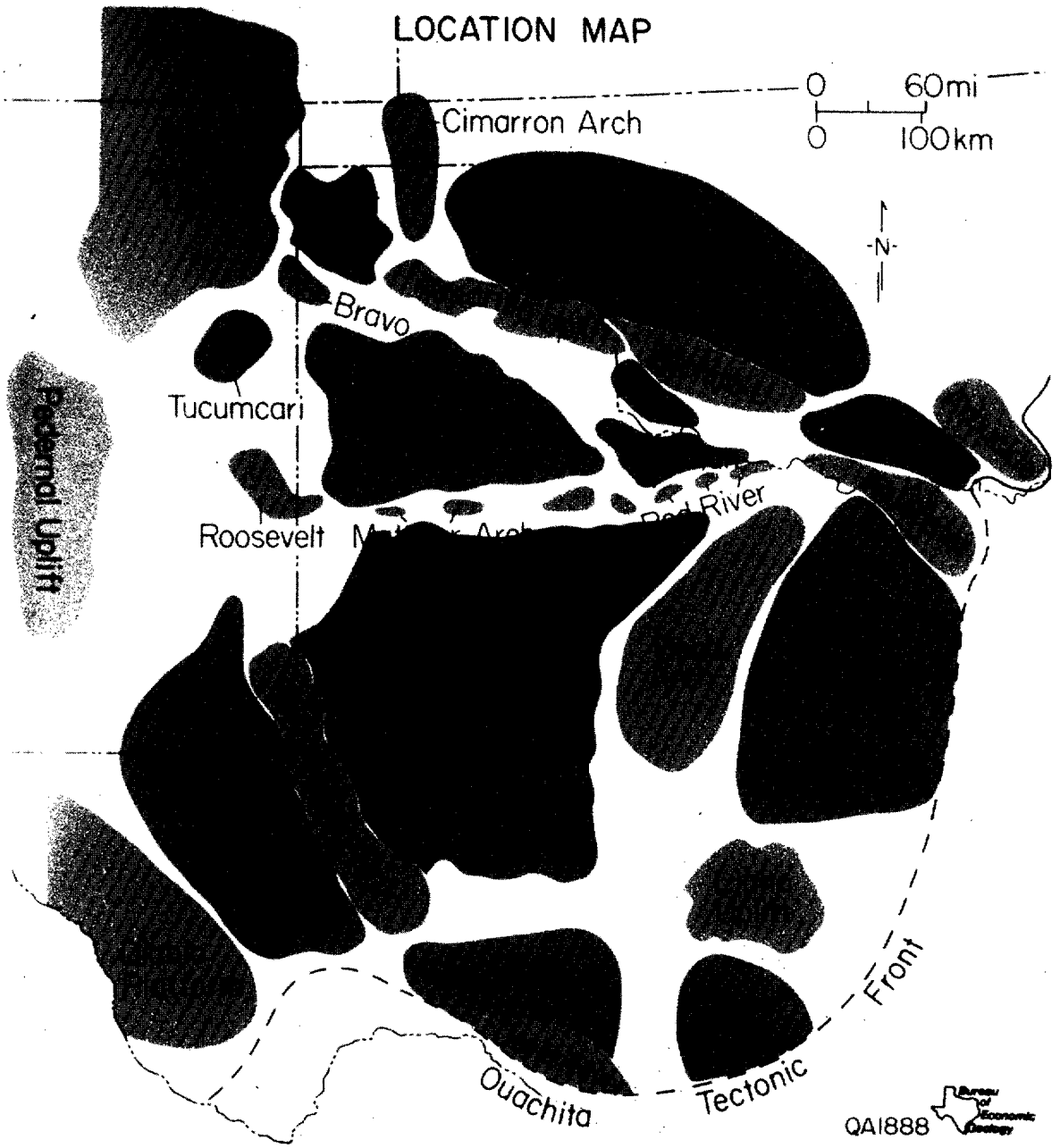
Distribution of pre-Ellenburger Group arkose in Castro Trough

- Well control
- ⊙ Wells penetrating pre-Ellenburger arkose

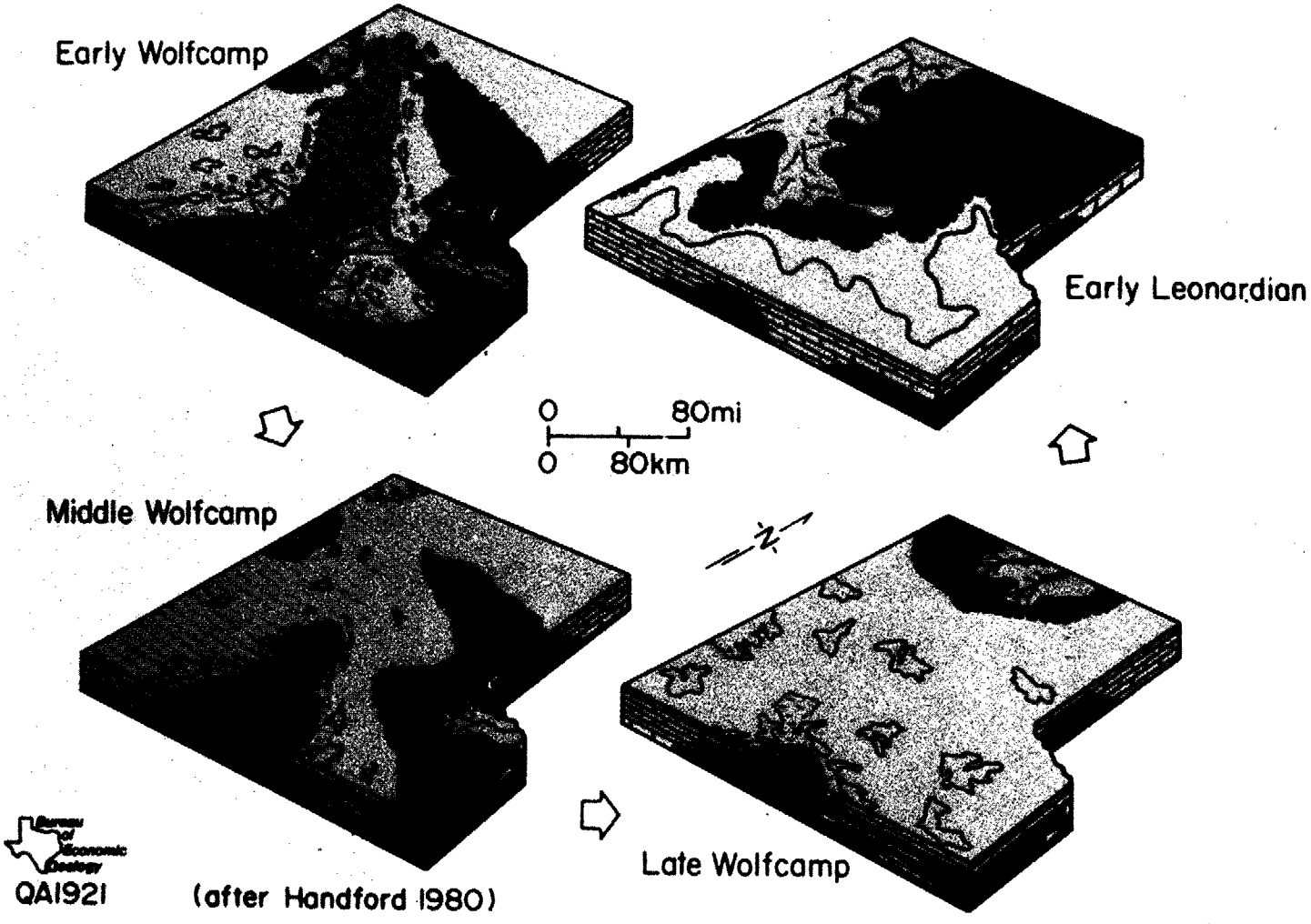
0 10 mi
0 10 km

Block diagram of basement surface of Amarillo Uplift




LOCATION MAP
0 60mi
0 100km
Cimarron Arch
N
Bravo
Tucumcari
Roosevelt
Red River
Front
Ouachita
Tectonic
QA1888

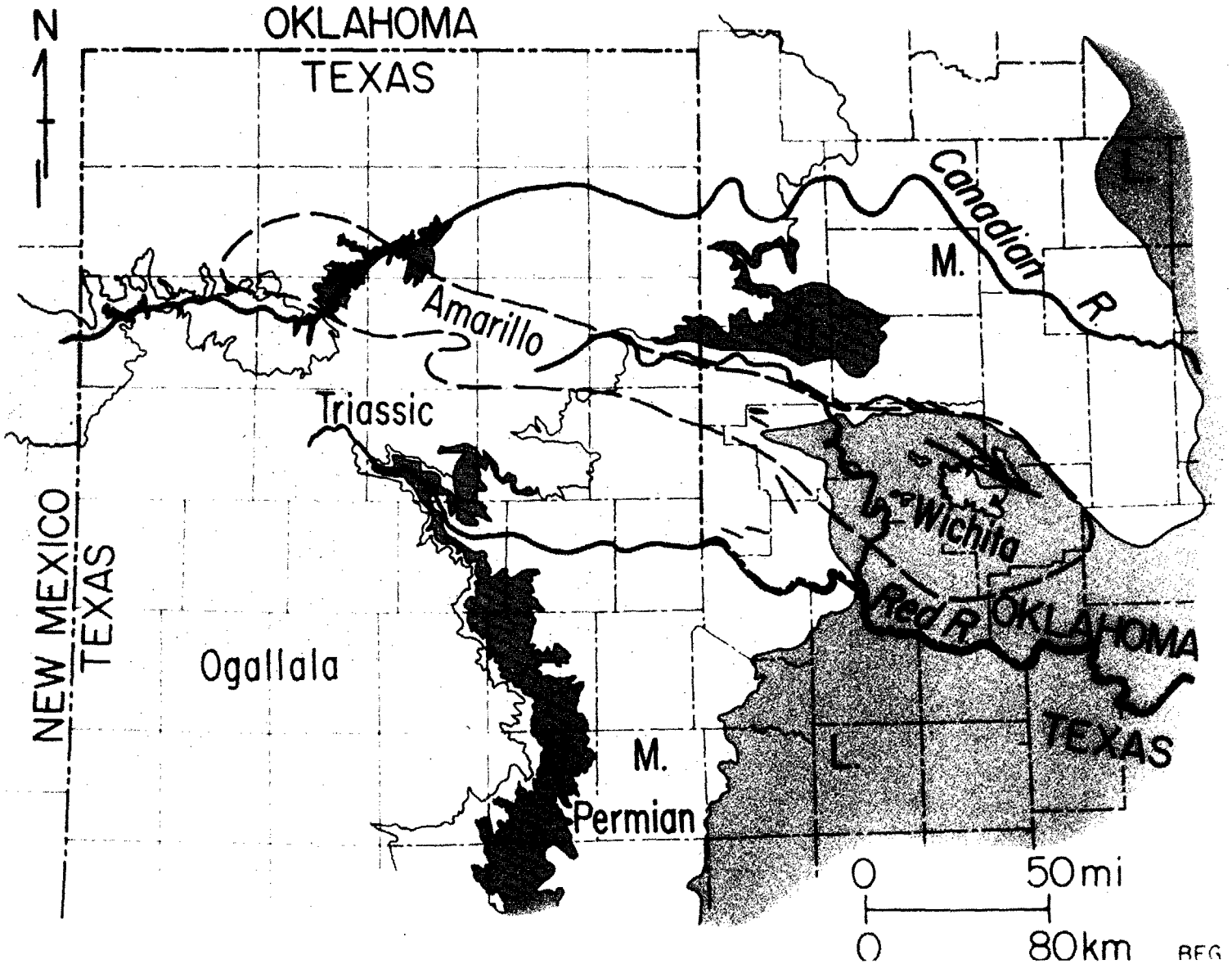
PALEOGEOGRAPHIC EVOLUTION OF PALO DURO BASIN



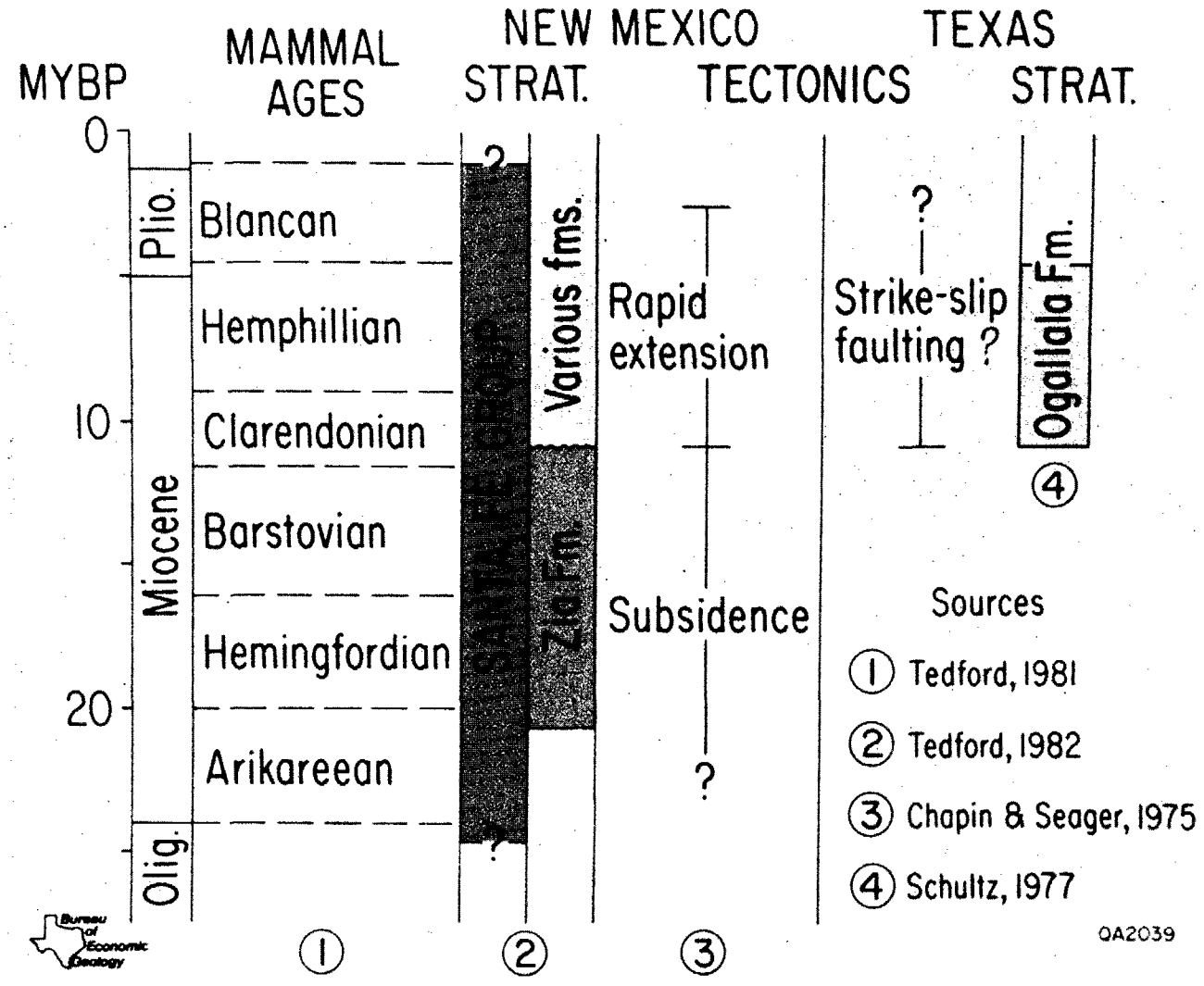
Bureau of Economic Geology

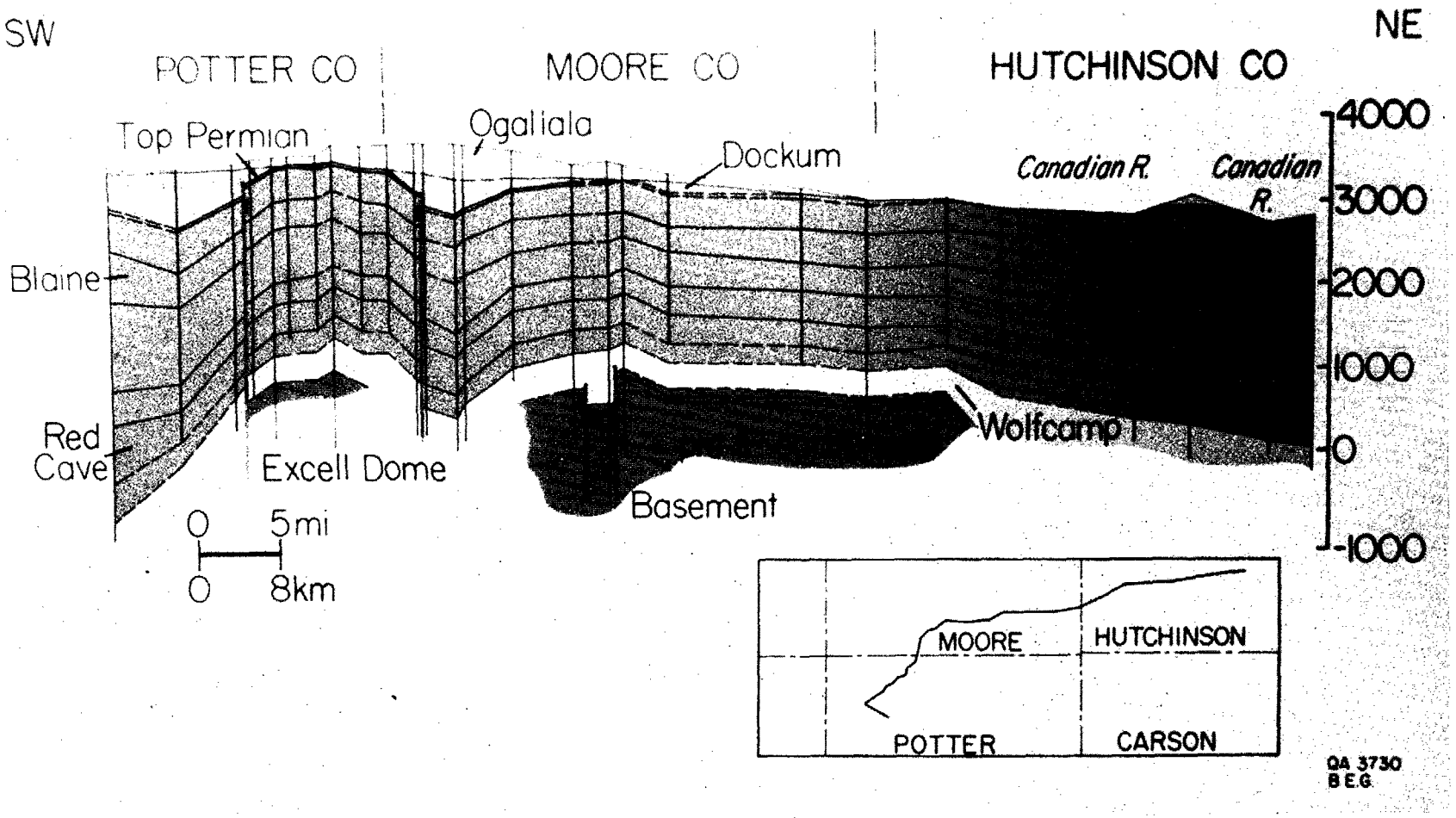
QA1921

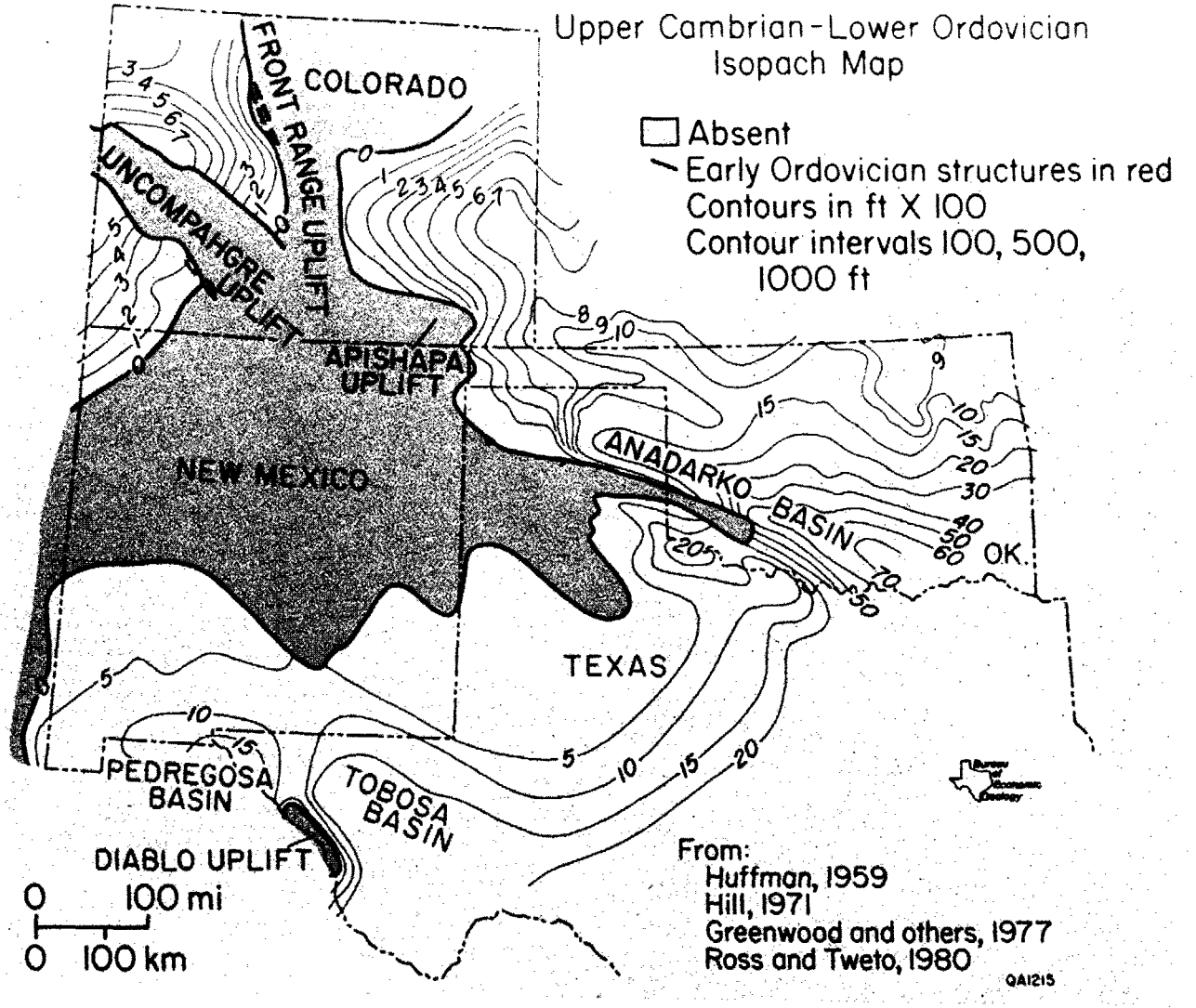
(after Handford 1980)


N
OKLAHOMA
TEXAS
Canadian R.
M.
L.
Amarillo
Triassic
Wichita
Red R.
OKLAHOMA
TEXAS
NEW MEXICO
TEXAS
Ogallala
M.
Permian
L.
0
50 mi
0
80 km
BEG

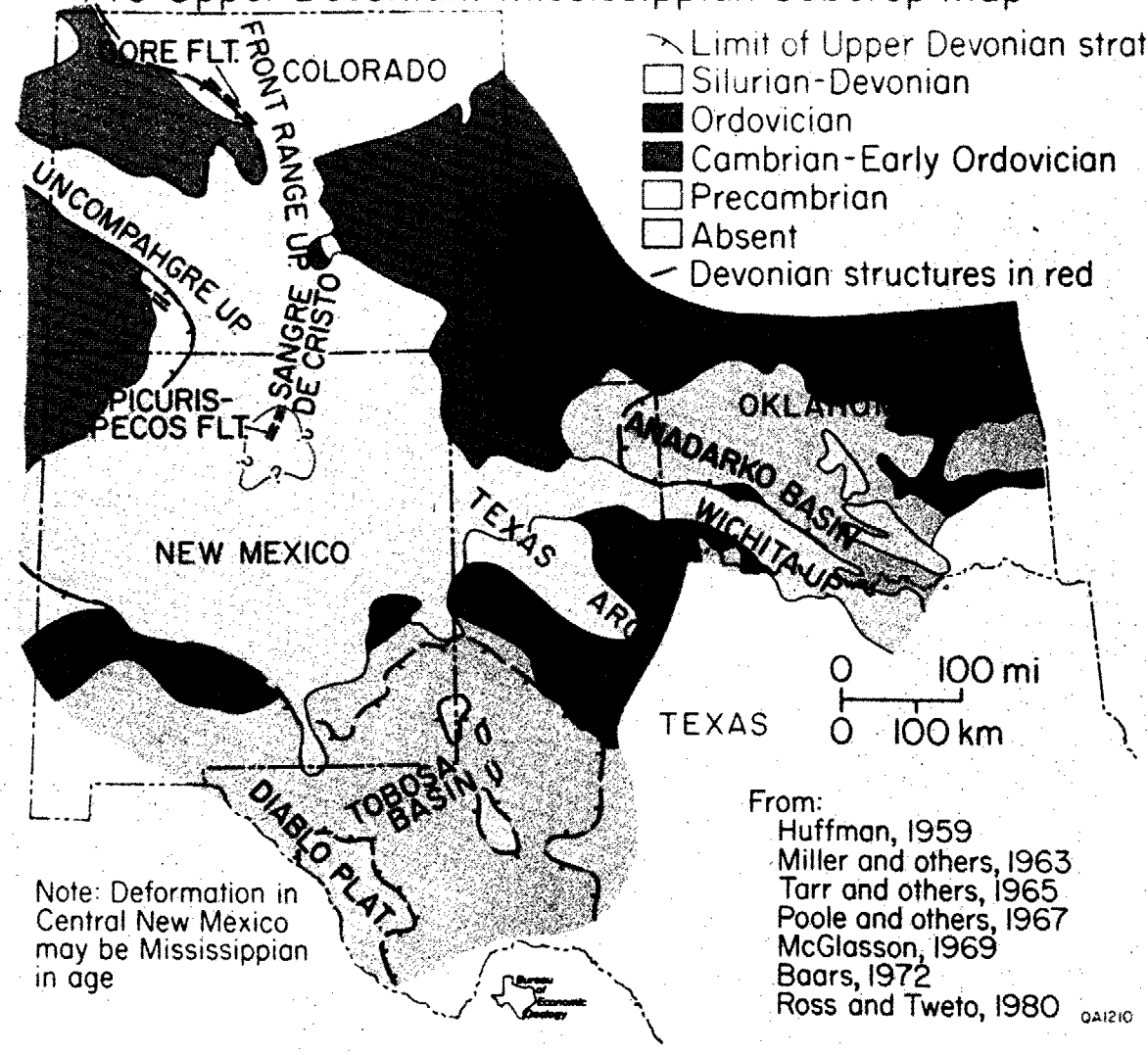
CORRELATION CHART



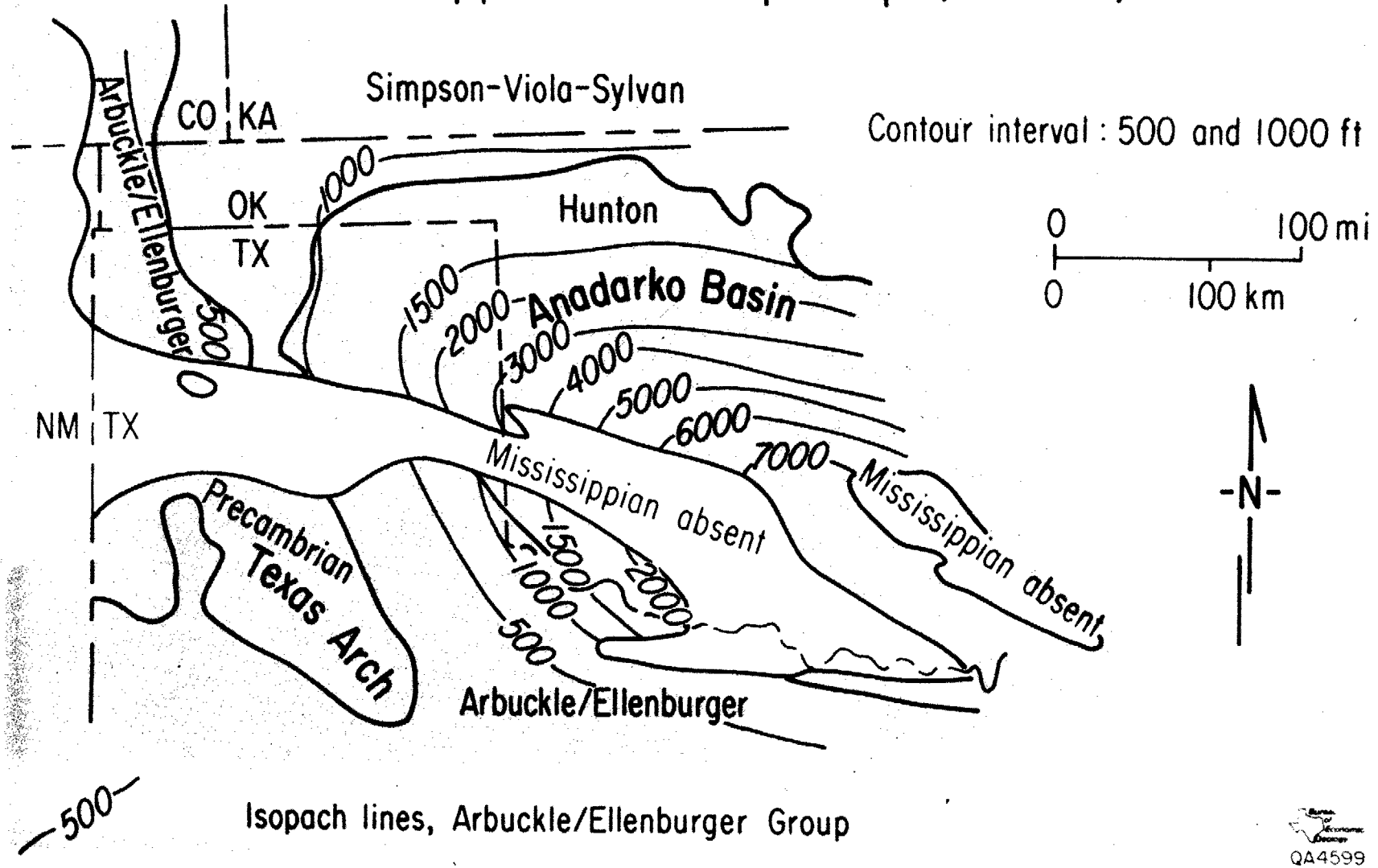

SW
NE
POTTER CO
MOORE CO
HUTCHINSON CO
Top Permian
Ogallala
Dockum
Canadian R.
Canadian R.
Blaine
Red Cave
Excell Dome
Wolfcamp
Basement
4000
3000
2000
1000
0
-1000
0 5mi
0 8km
MOORE
HUTCHINSON
POTTER
CARSON
QA 3730
B.E.G.


Upper Cambrian-Lower Ordovician
Isopach Map
Absent
Early Ordovician structures in red
Contours in ft X 100
Contour intervals 100, 500,
1000 ft
COLORADO
FRONT RANGE UPLIFT
UNCOMPAHGRE UPLIFT
APISHAPA UPLIFT
NEW MEXICO
ANADARKO BASIN
OK
TEXAS
PEDREGOSA BASIN
TOBOSA BASIN
DIABLO UPLIFT
0 100 mi
0 100 km
From:
Huffman, 1959
Hill, 1971
Greenwood and others, 1977
Ross and Tweto, 1980
QA1215

Pre-Upper Devonian/Mississippian Subcrop Map

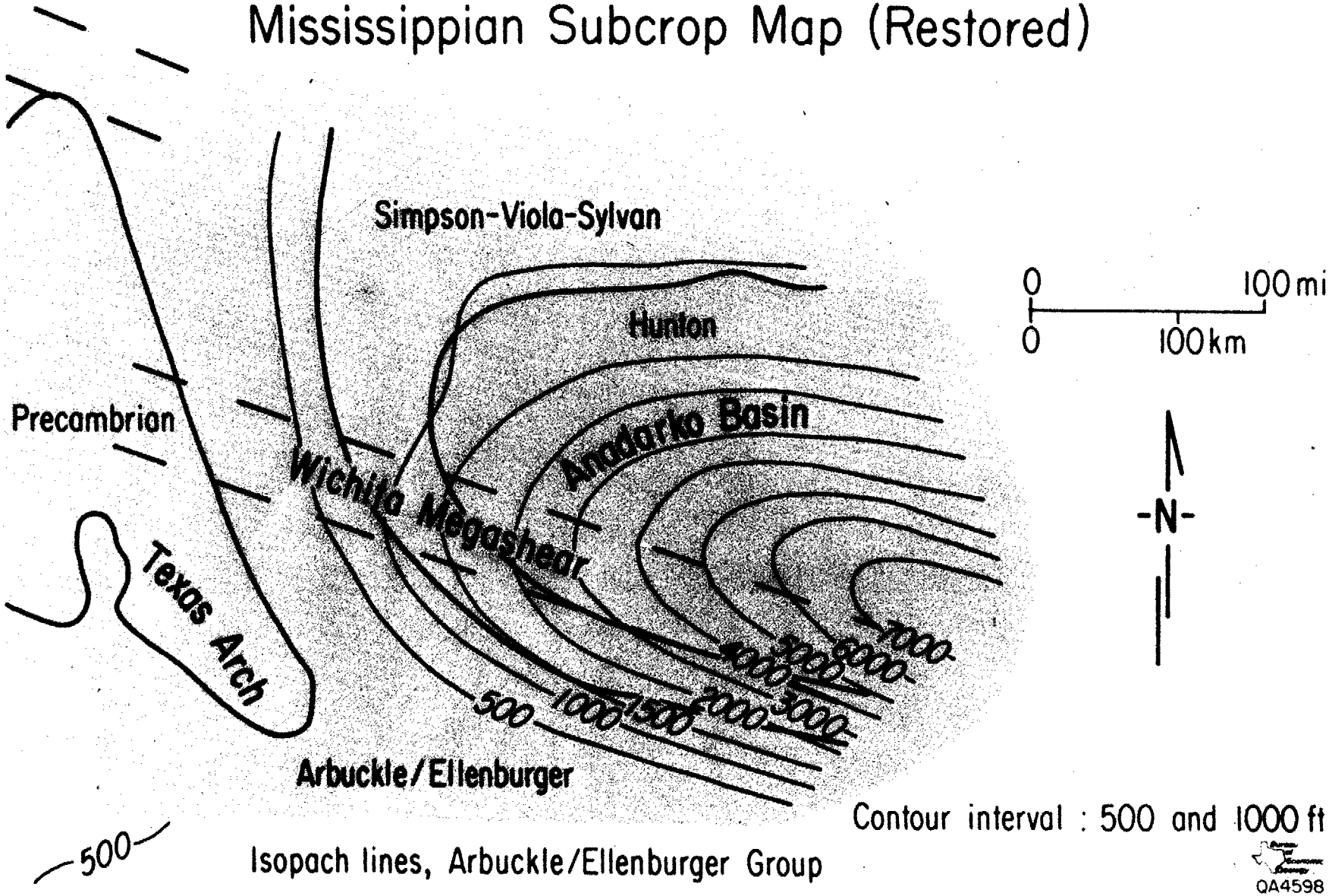


Mississippian Subcrop Map (Present)

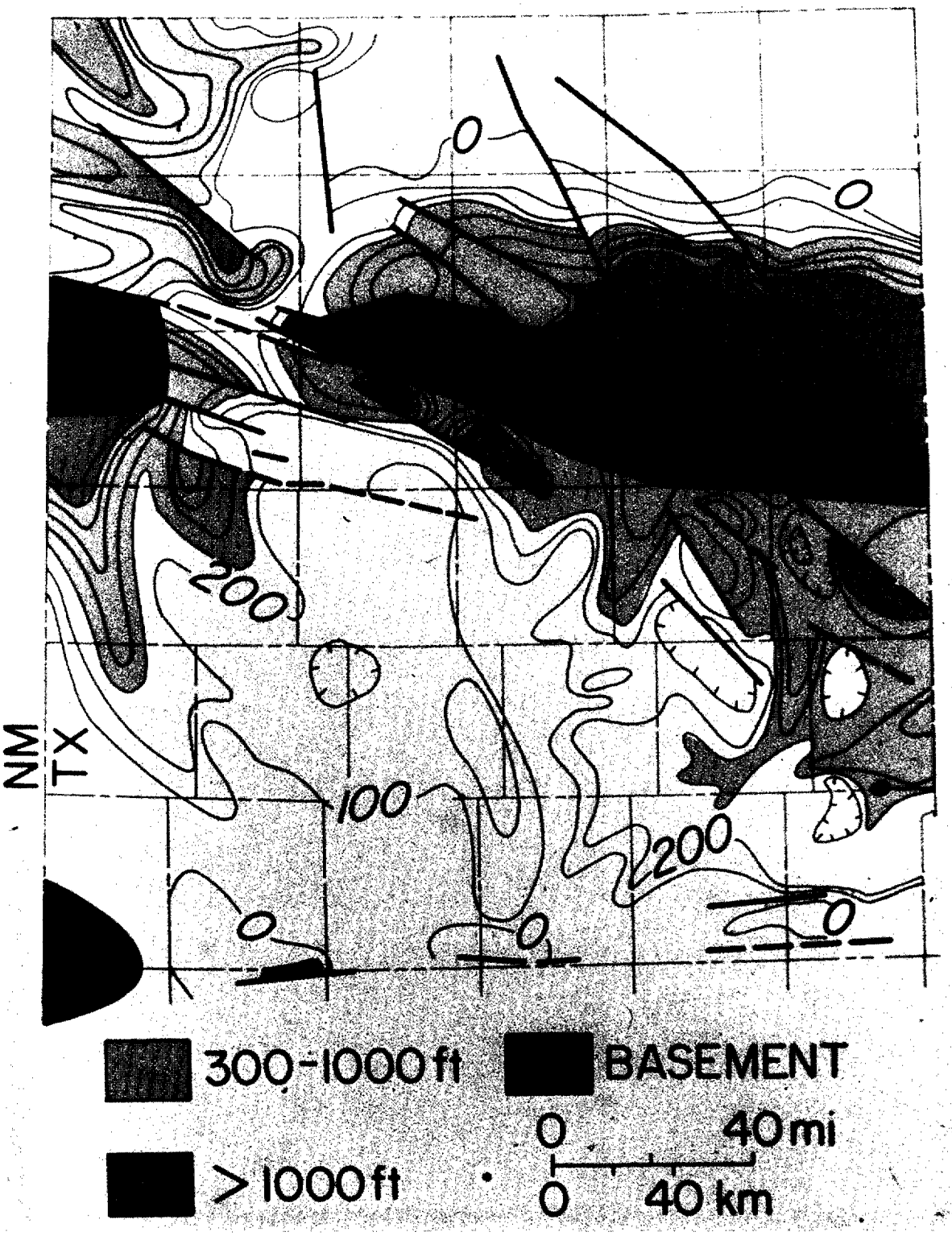


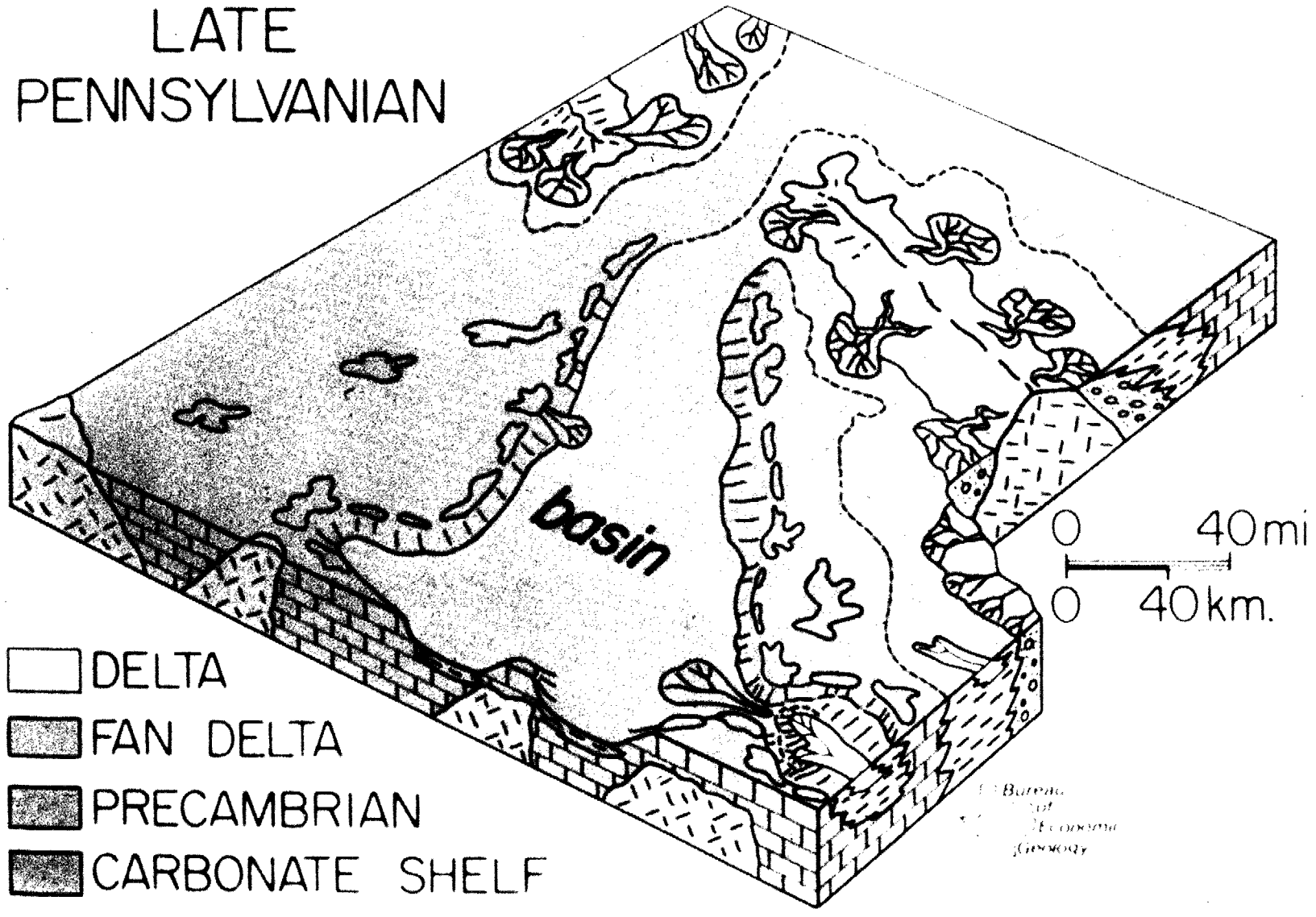
QA4599

Mississippian Subcrop Map (Restored)



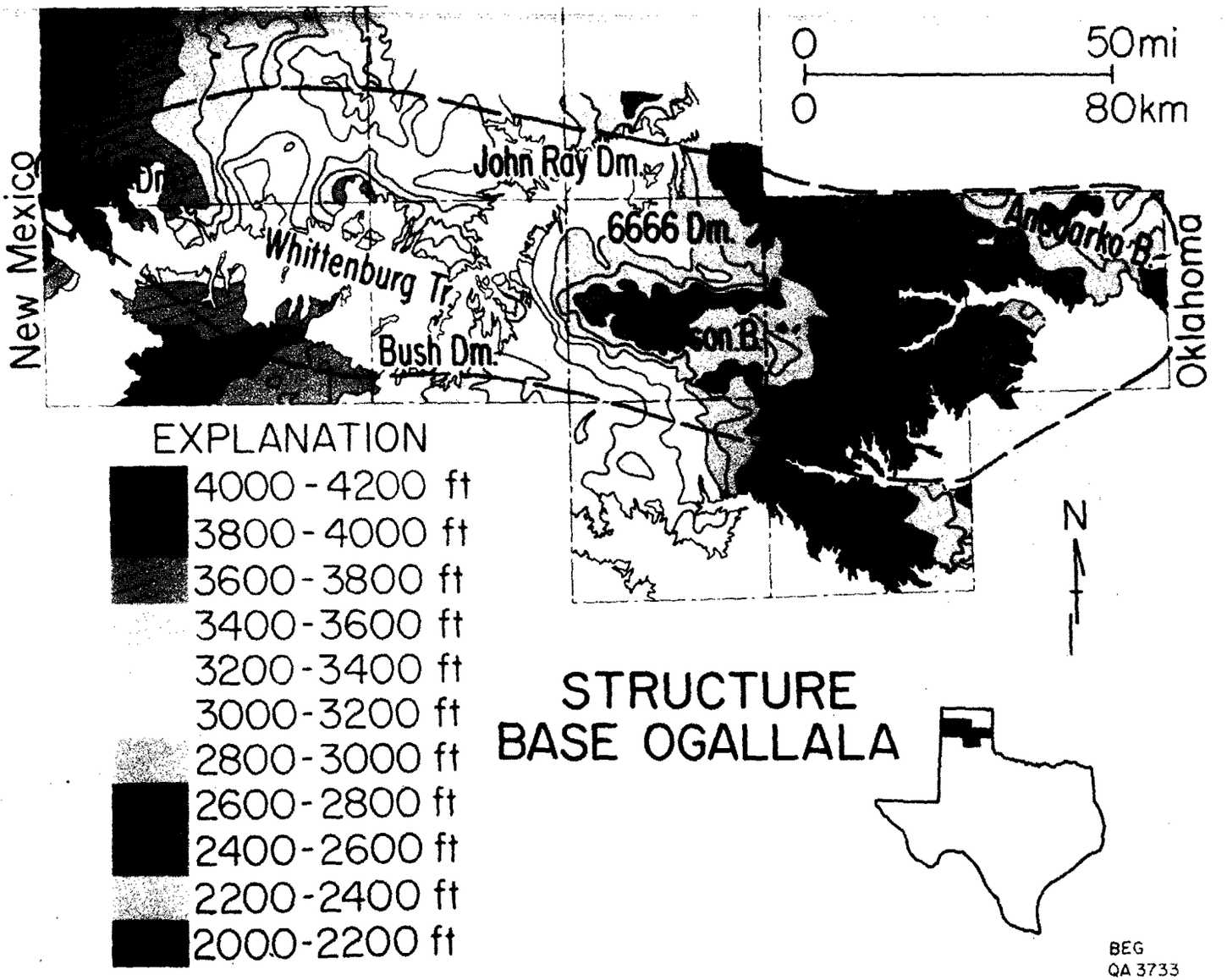
NET GRANITE WASH



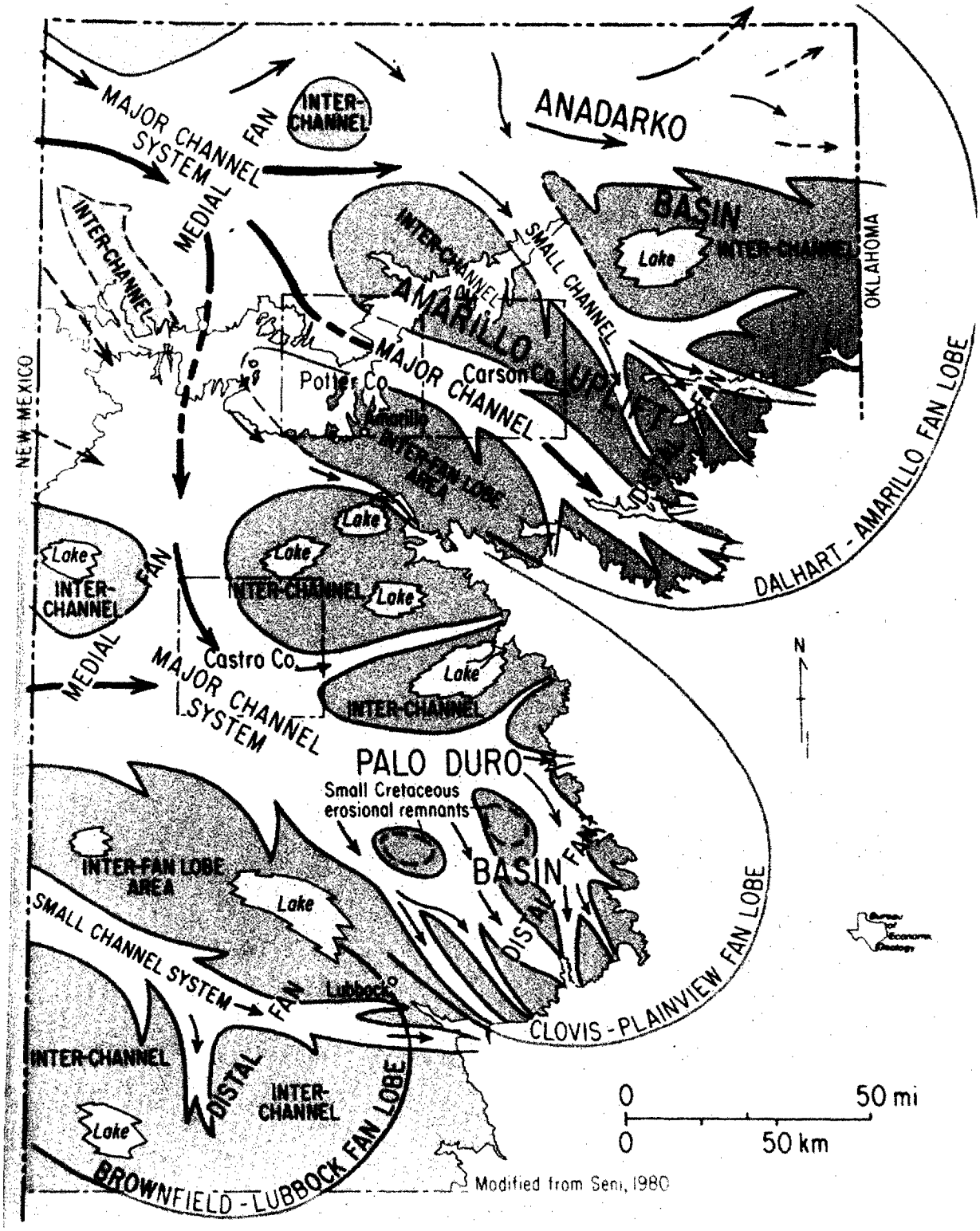

LATE
PENNSYLVANIAN
basin
0 40mi
0 40km.
DELTA
FAN DELTA
PRECAMBRIAN
CARBONATE SHELF

ISOPACH
PERMIAN post Wolfcamp

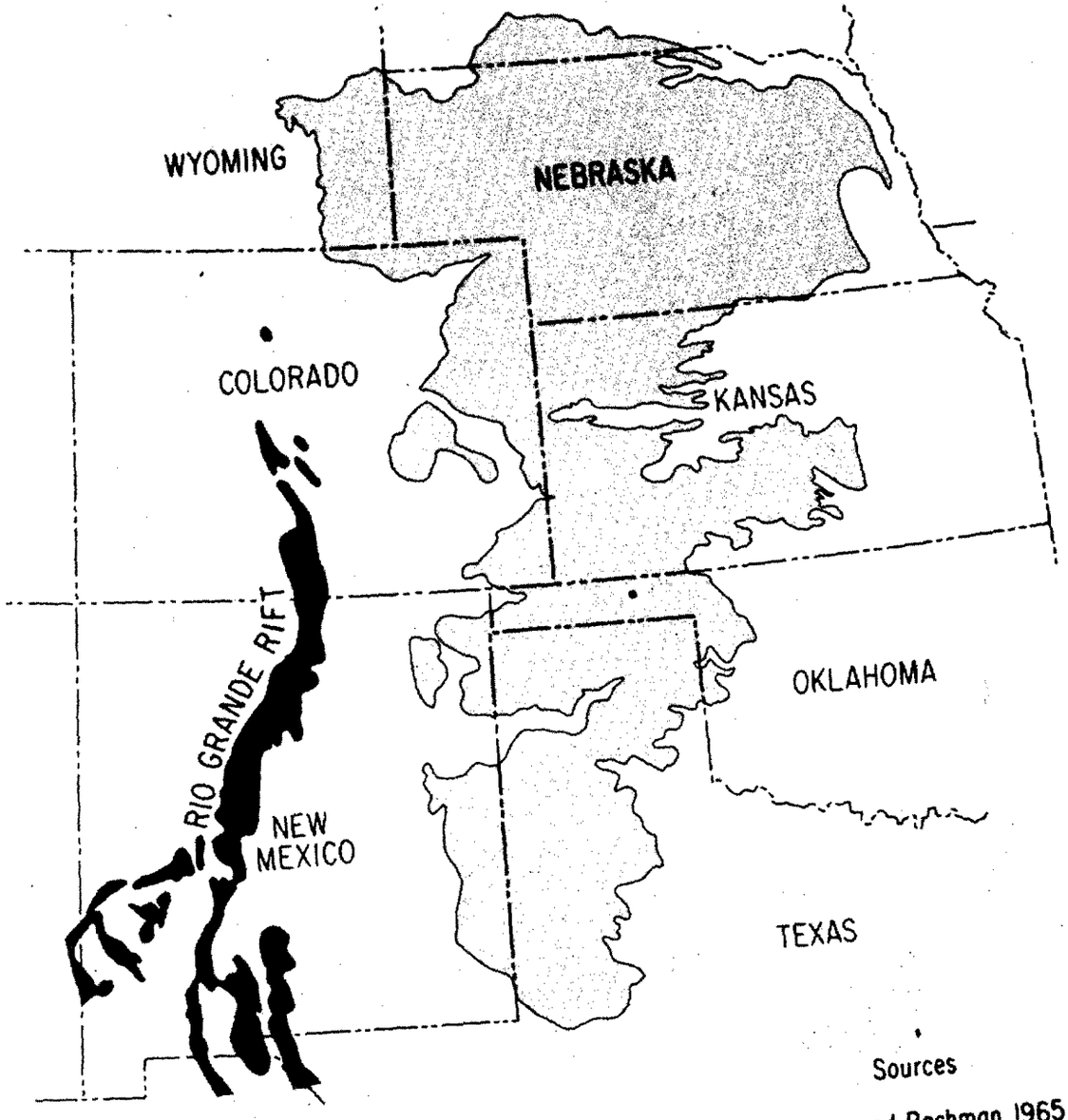
BEG
QA-3223


0 50mi
0 80km
New Mexico
Oklahoma
John Ray Dm.
6666 Dm.
Whittenburg Tr.
Bush Dm.
Anadarko B.
EXPLANATION
4000 - 4200 ft
3800 - 4000 ft
3600 - 3800 ft
3400 - 3600 ft
3200 - 3400 ft
3000 - 3200 ft
2800 - 3000 ft
2600 - 2800 ft
2400 - 2600 ft
2200 - 2400 ft
2000 - 2200 ft
N
STRUCTURE
BASE OGALLALA
BEG
QA 3733

DEPOSITIONAL PATTERNS OF OGALLALA FM.



DISTRIBUTION OF NEOGENE SEDIMENTS



Ogallala Fm.

Santa Fe and related fms.

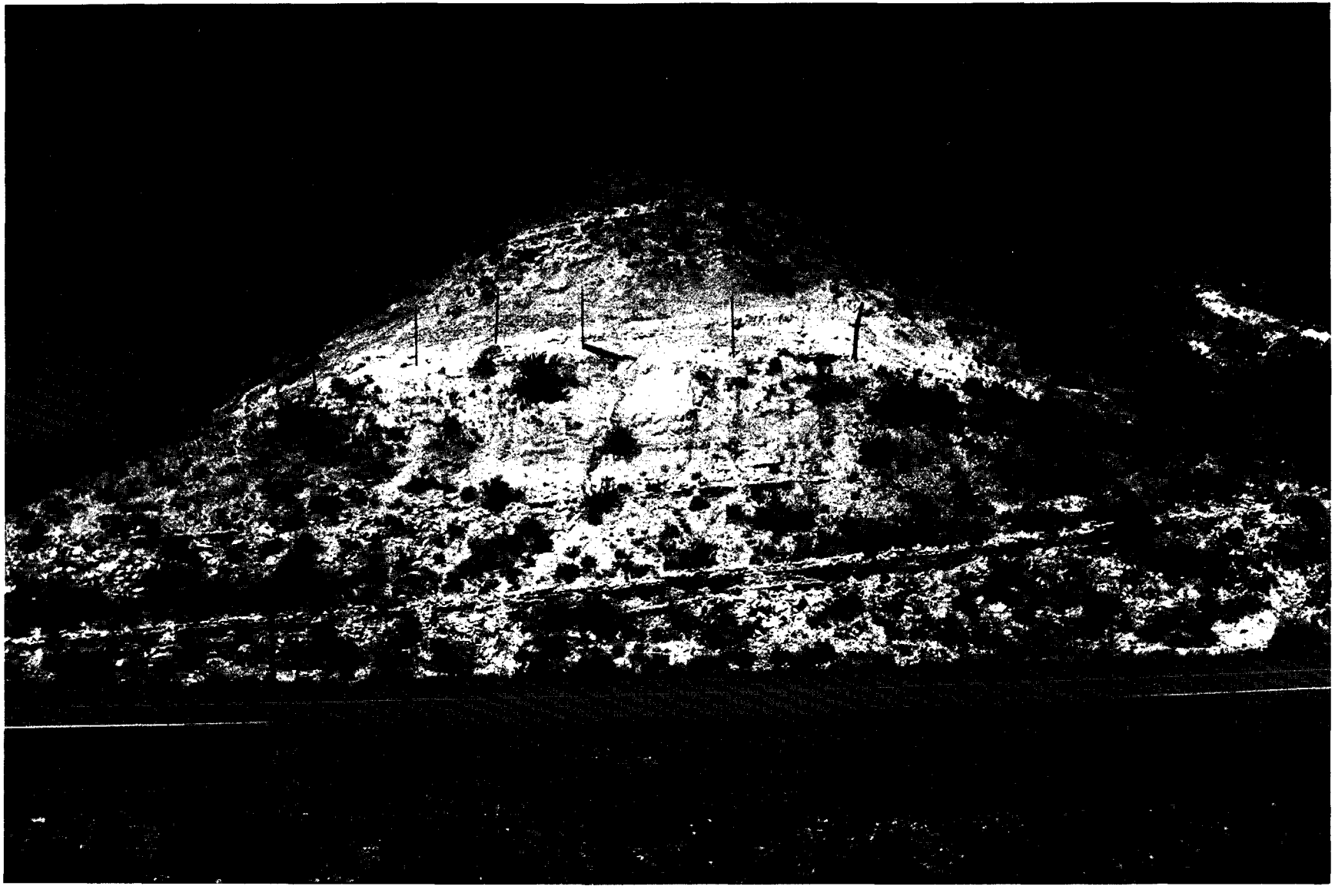
0 200 mi

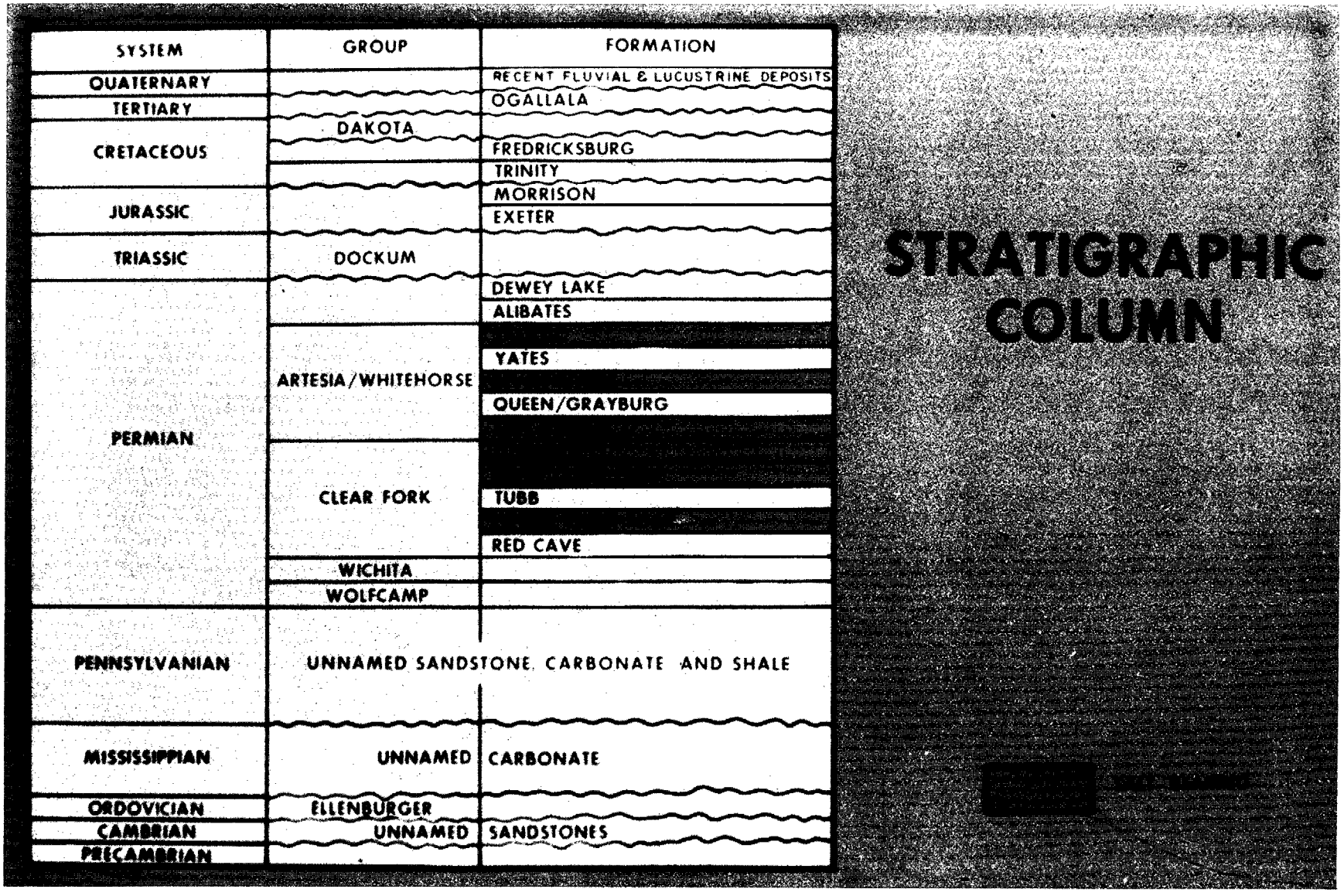
0 200 km

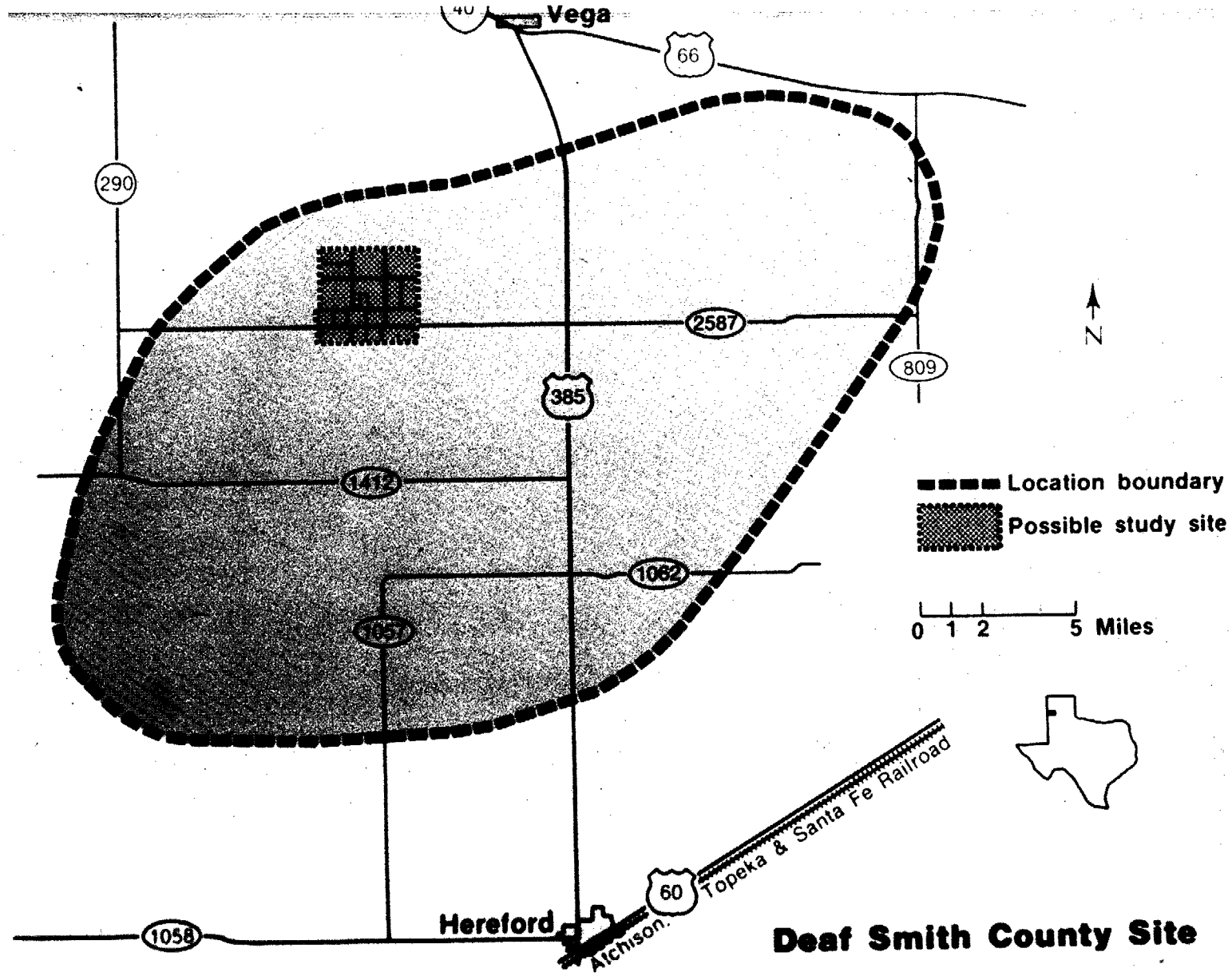
Sources

Dane and Bachman, 1965
Knepper, 1976
Tedford, 1981
Weeks and Gutentag, 1981

QA2038



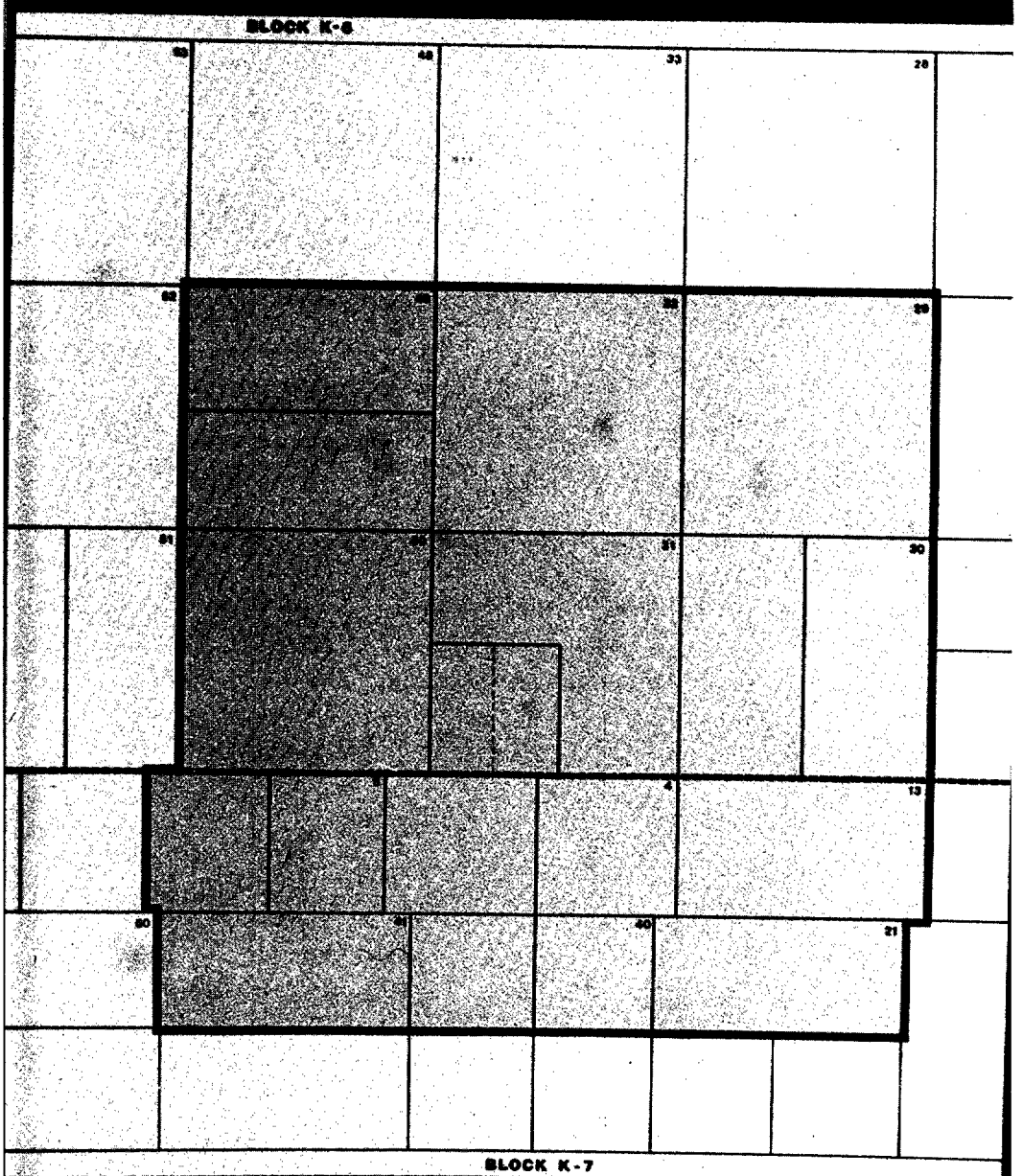

STRATIGRAPHIC COLUMN
SYSTEM
GROUP
FORMATION
QUATERNARY
RECENT FLUVIAL & LUCUSTRINE DEPOSITS
TERTIARY
OGALLALA
CRETACEOUS
DAKOTA
FREDRICKSBURG
TRINITY
JURASSIC
MORRISON
EXETER
TRIASSIC
DOCKUM
DEWEY LAKE
ALIBATES
PERMIAN
ARTESIA/WHITEHORSE
YATES
QUEEN/GRAYBURG
CLEAR FORK
TUBB
RED CAVE
WICHITA
WOLFCAMP
PENNSYLVANIAN
UNNAMED SANDSTONE, CARBONATE AND SHALE
MISSISSIPPIAN
UNNAMED
CARBONATE
ORDOVICIAN
ELLENBURGER
CAMBRIAN
UNNAMED
SANDSTONES
PRECAMBRIAN



Deaf Smith County Site

Possible 9-Square-Mile Study Site Deaf Smith County, Texas

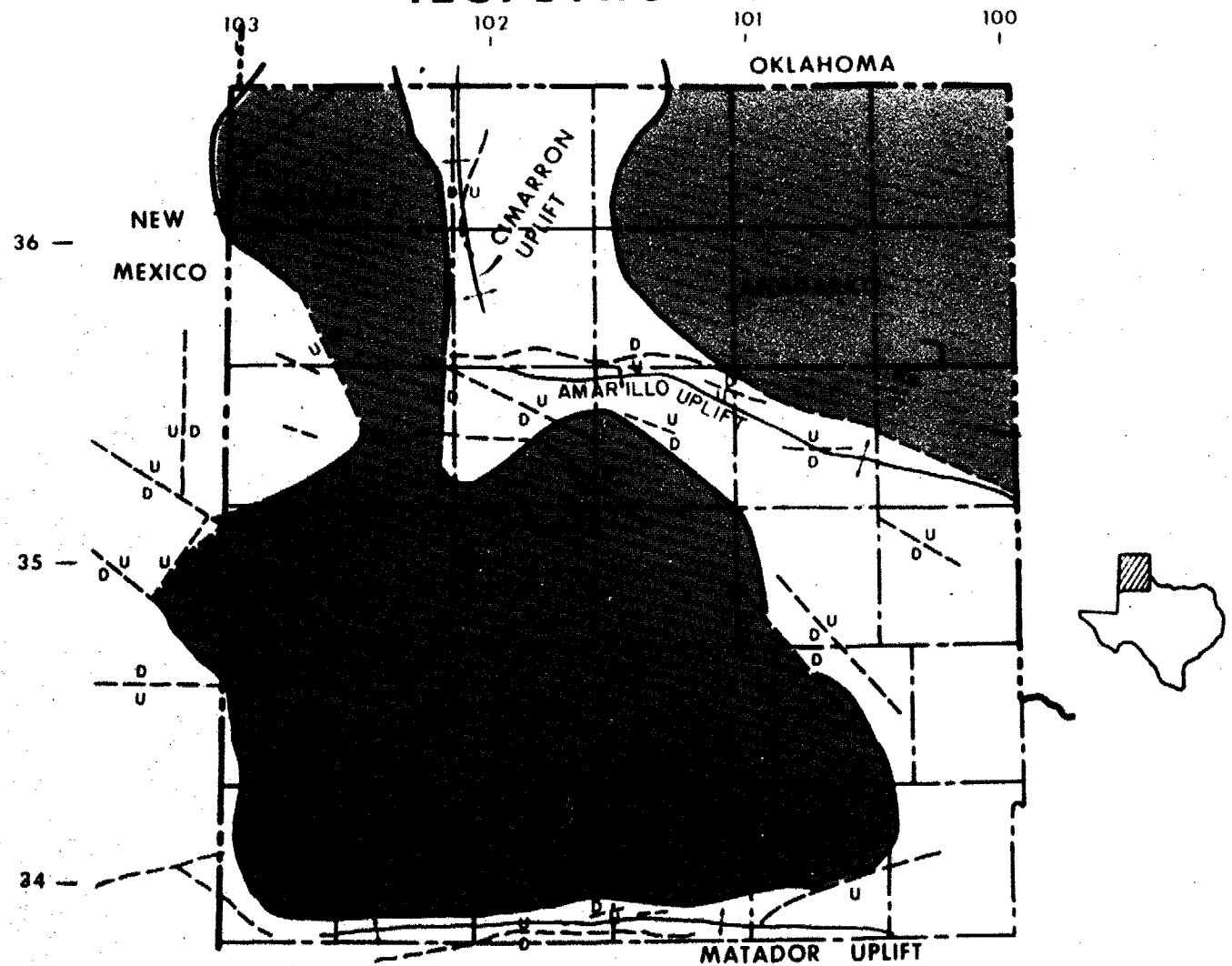
G.B.&C.N.G. RR

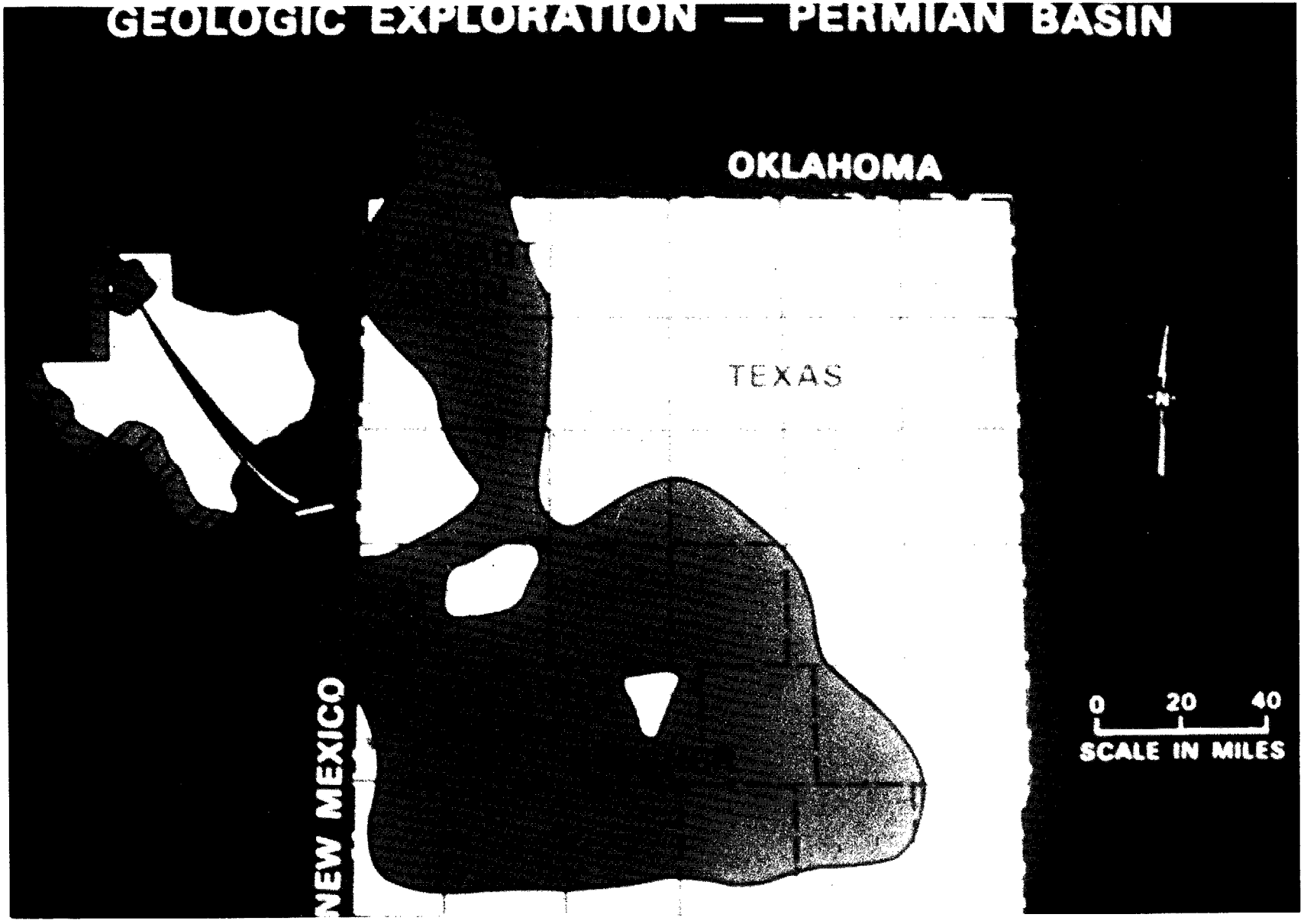


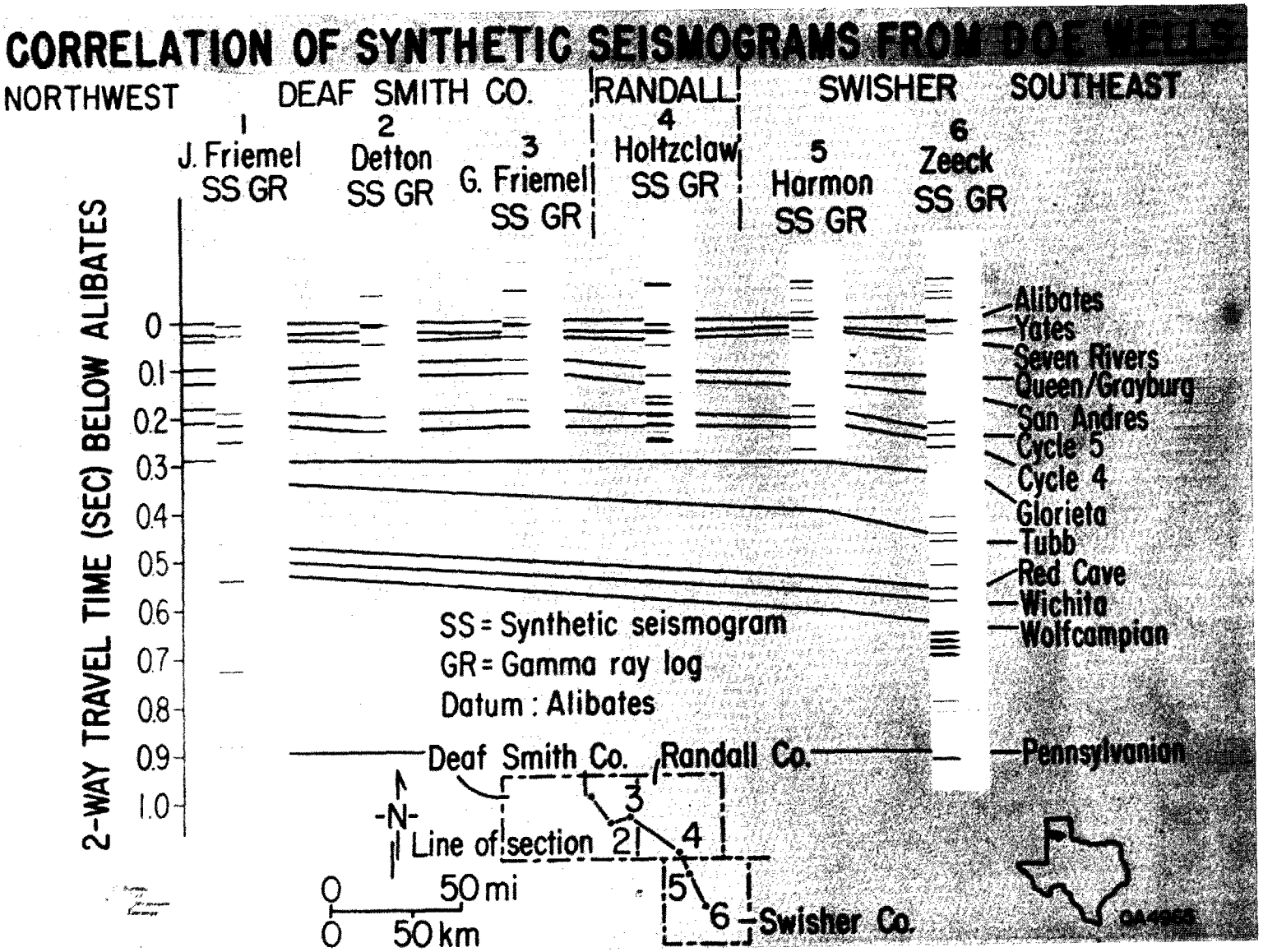
Possible study site boundary

Block boundary

TECTONIC MAP

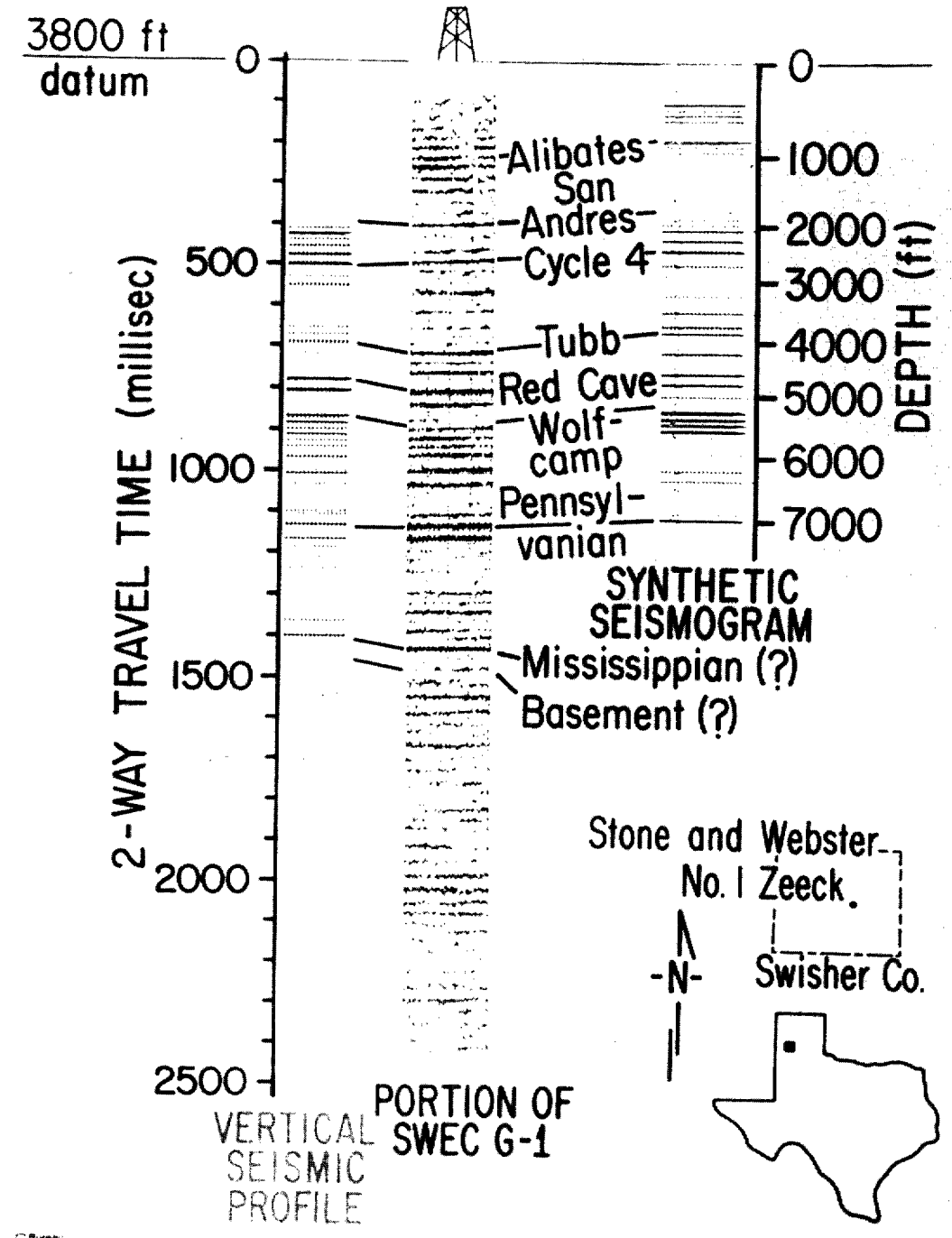



GEOLOGIC EXPLORATION — PERMIAN BASIN
OKLAHOMA
TEXAS
NEW MEXICO
0 20 40
SCALE IN MILES

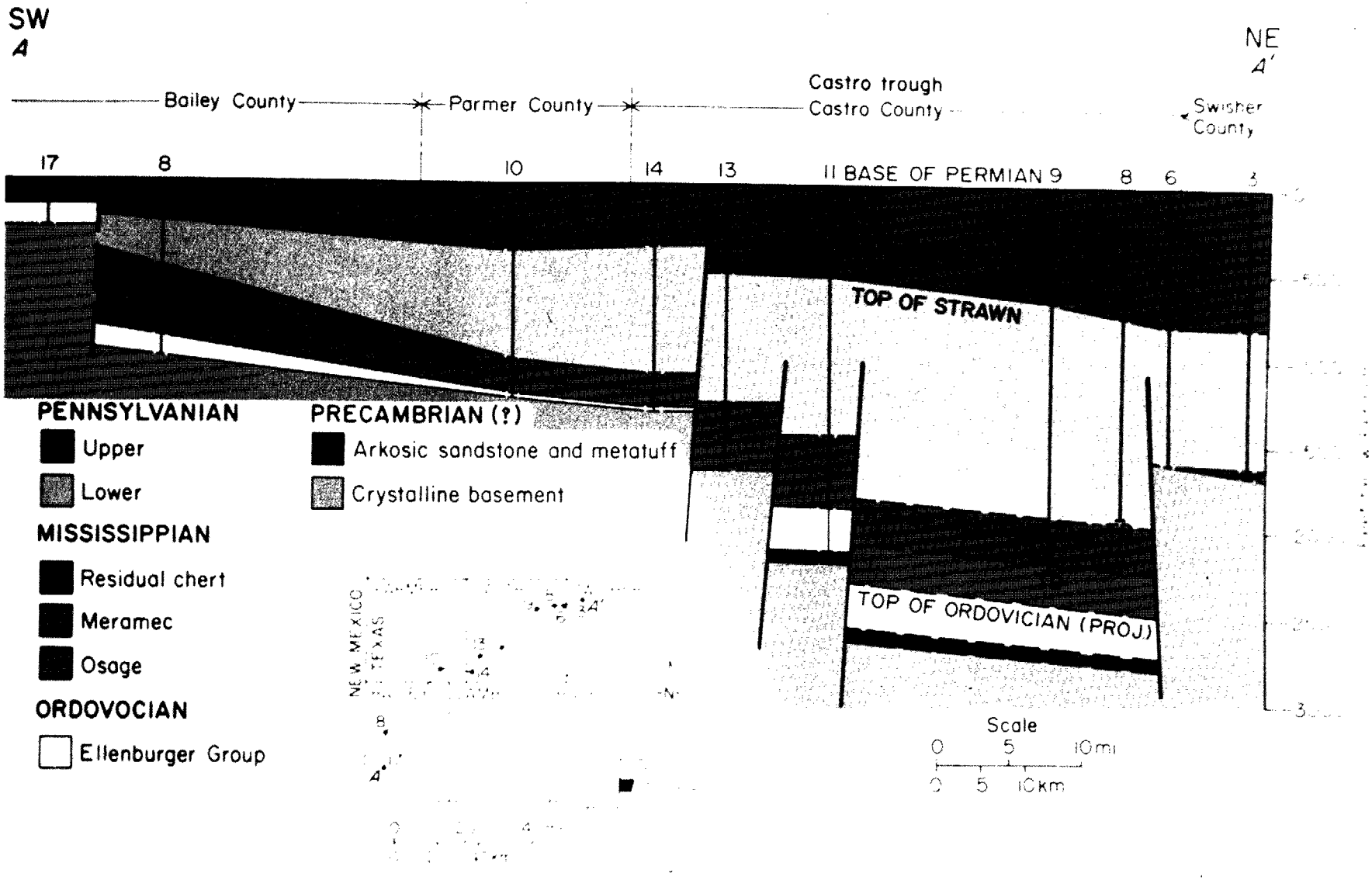

CORRELATION OF SYNTHETIC SEISMOGRAMS FROM DOE WELLS
NORTHWEST
DEAF SMITH CO.
RANDALL
SWISHER
SOUTHEAST
1
J. Friemel
SS GR
2
Detton
SS GR
3
G. Friemel
SS GR
4
Holtzclaw
SS GR
5
Harmon
SS GR
6
Zeeck
SS GR
2-WAY TRAVEL TIME (SEC) BELOW ALIBATES
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Alibates
Yates
Seven Rivers
Queen/Grayburg
San Andres
Cycle 5
Cycle 4
Glorieta
Tubb
Red Cave
Wichita
Wolfcampian
Pennsylvanian
SS = Synthetic seismogram
GR = Gamma ray log
Datum : Alibates
Deaf Smith Co.
Randall Co.
Swisher Co.
-N-
Line of section
0 50 mi
0 50 km

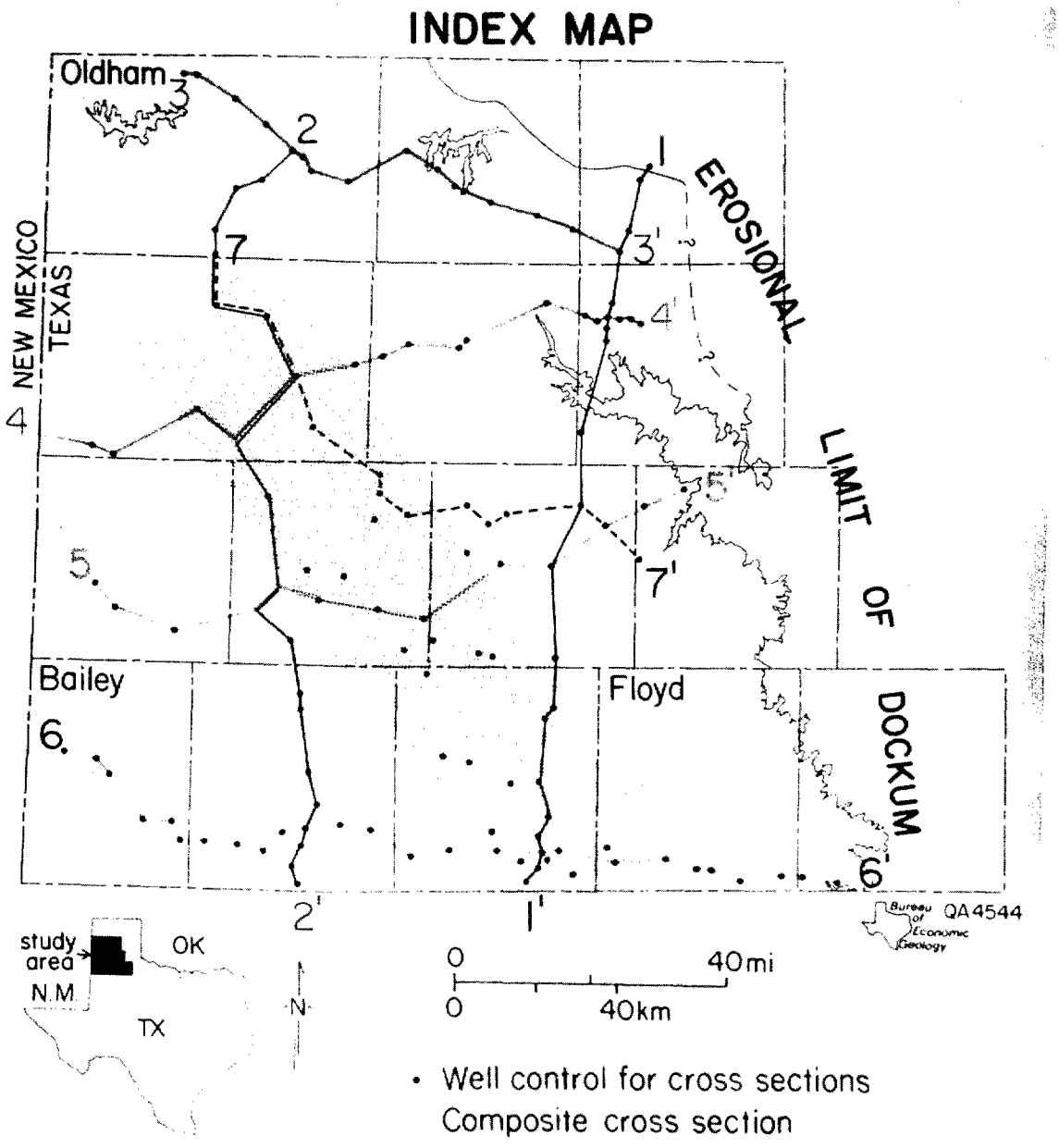
CORRELATION OF VSP, SYNTHETIC SEISMOGRAMS, & SEISMIC DATA

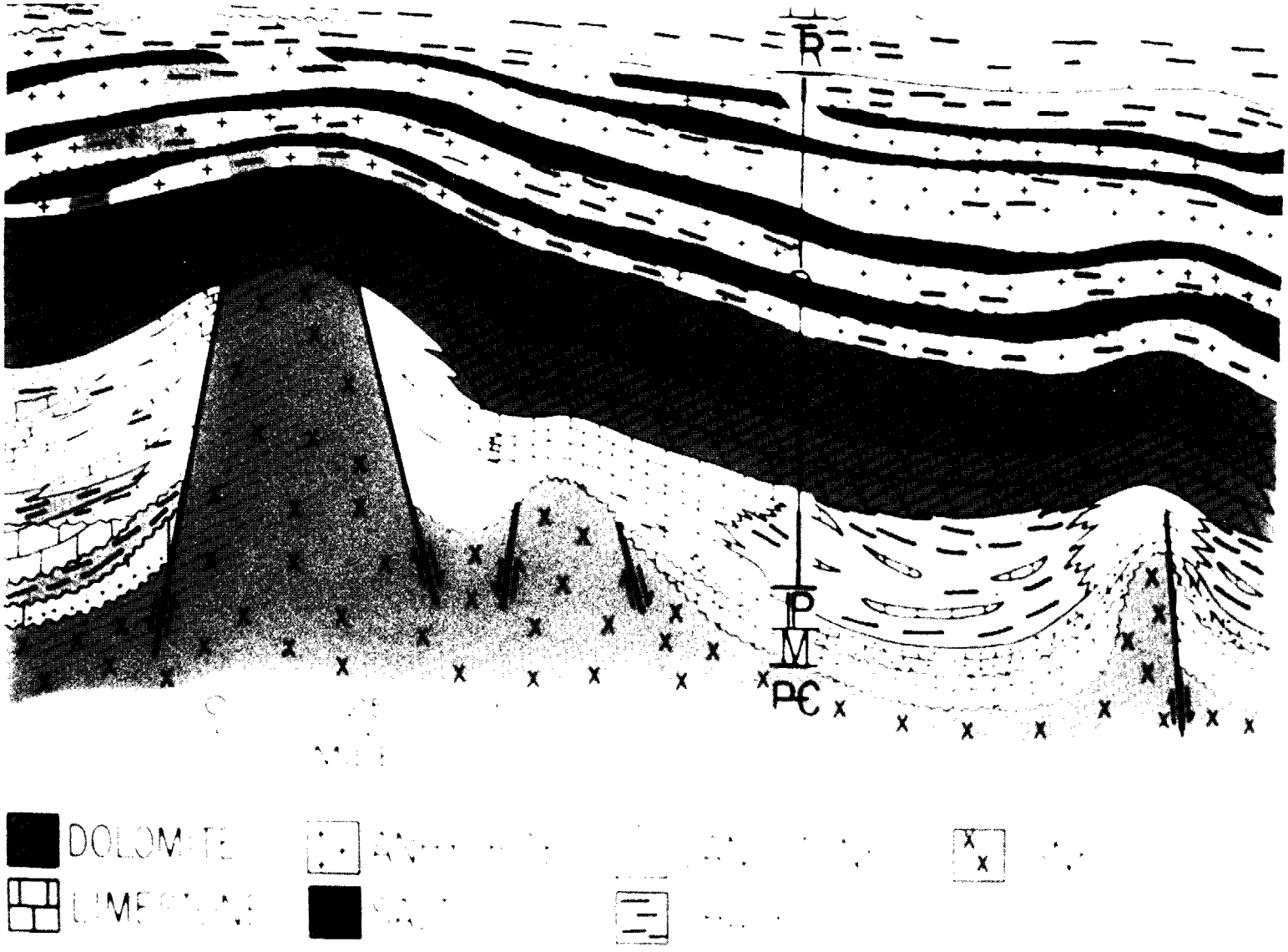
Stone and Webster
No. 1 Zeeck

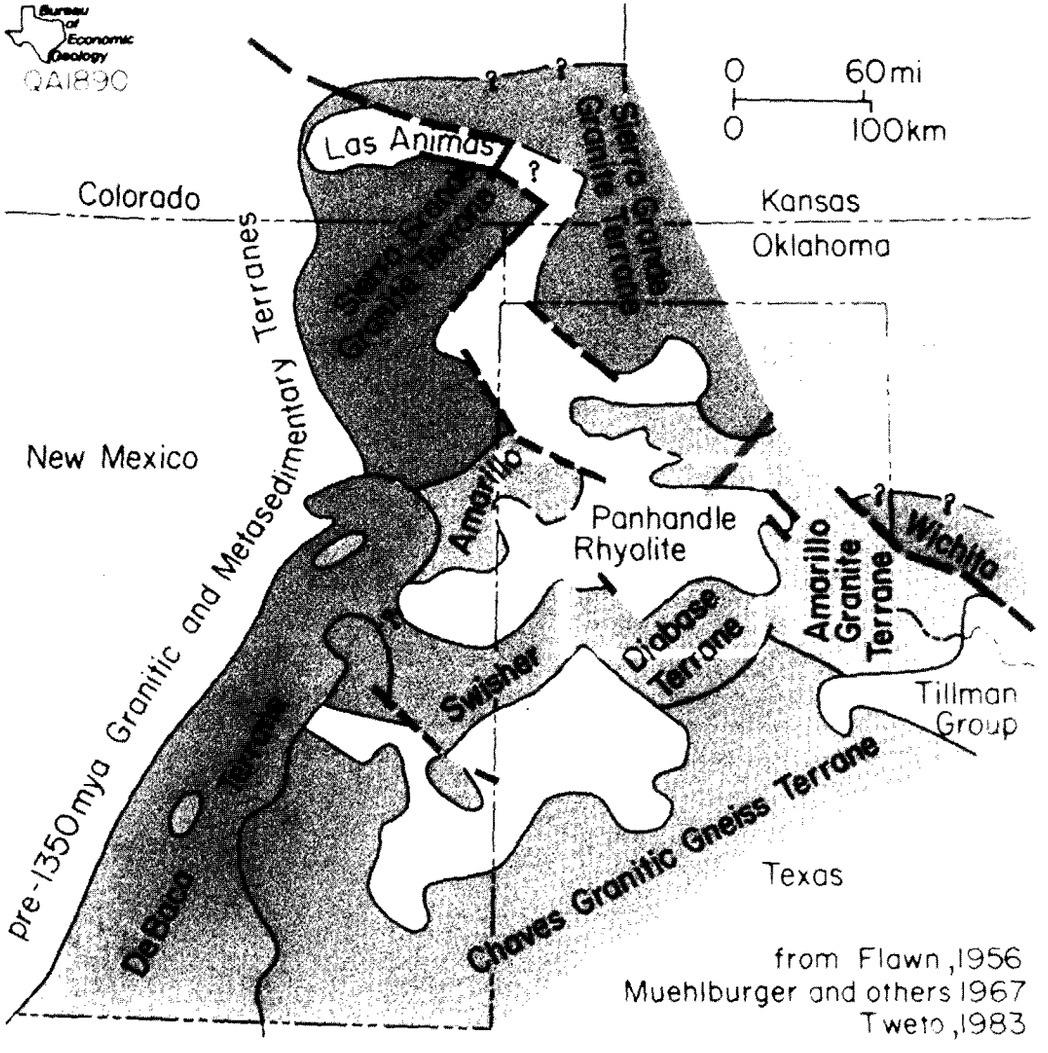


QA4966

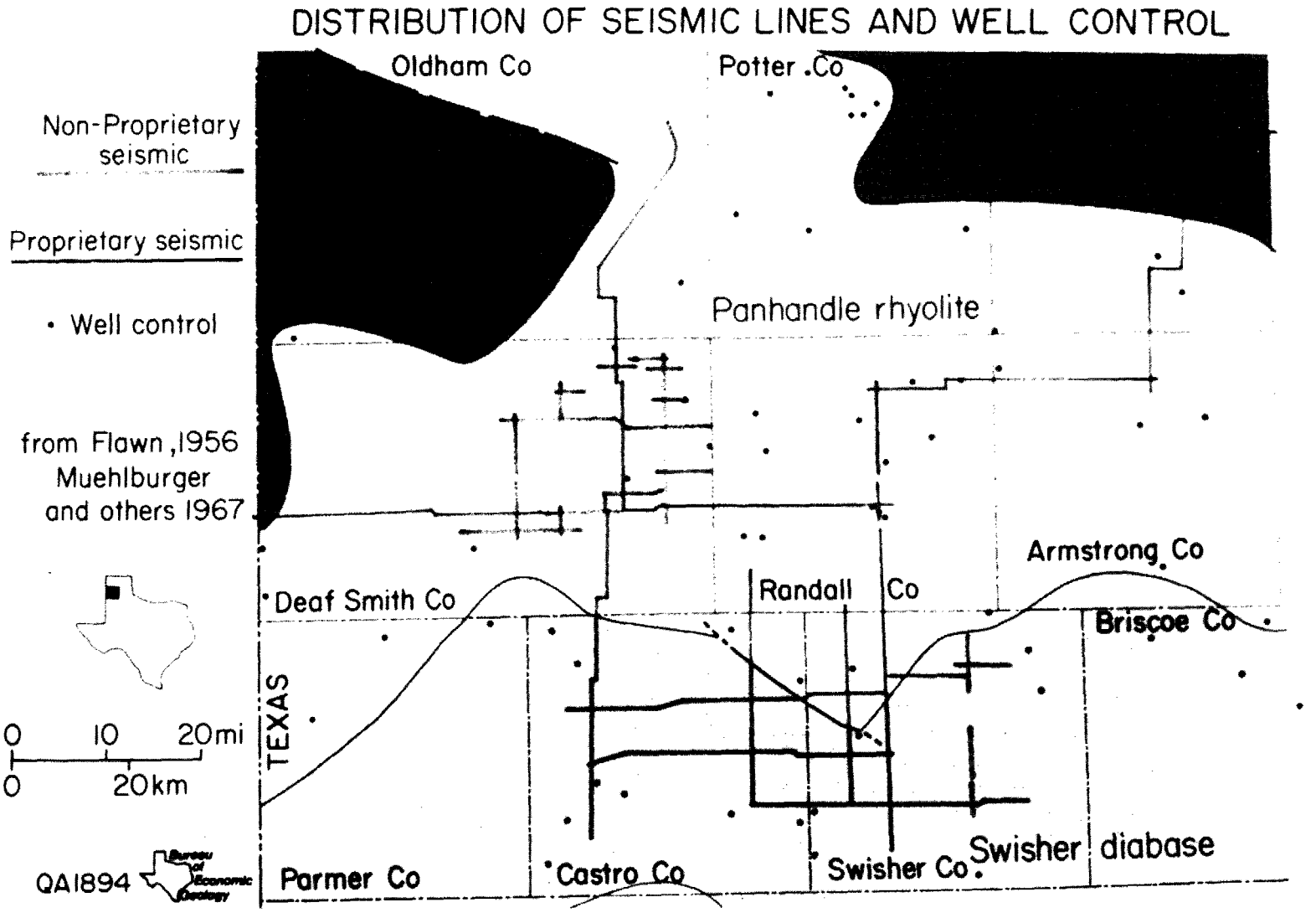

SW
A
NE
A'
Bailey County
Parmer County
Castro trough
Castro County
Swisher County
17
8
10
14
13
11 BASE OF PERMIAN 9
8
6
3
TOP OF STRAWN
TOP OF ORDOVICIAN (PROJ)
PENNSYLVANIAN
Upper
Lower
MISSISSIPPIAN
Residual chert
Meramec
Osage
ORDOVOCIAN
Ellenburger Group
PRECAMBRIAN (?)
Arkosic sandstone and metatuff
Crystalline basement
NEW MEXICO
TEXAS
Scale
0 5 10mi
0 5 10Km

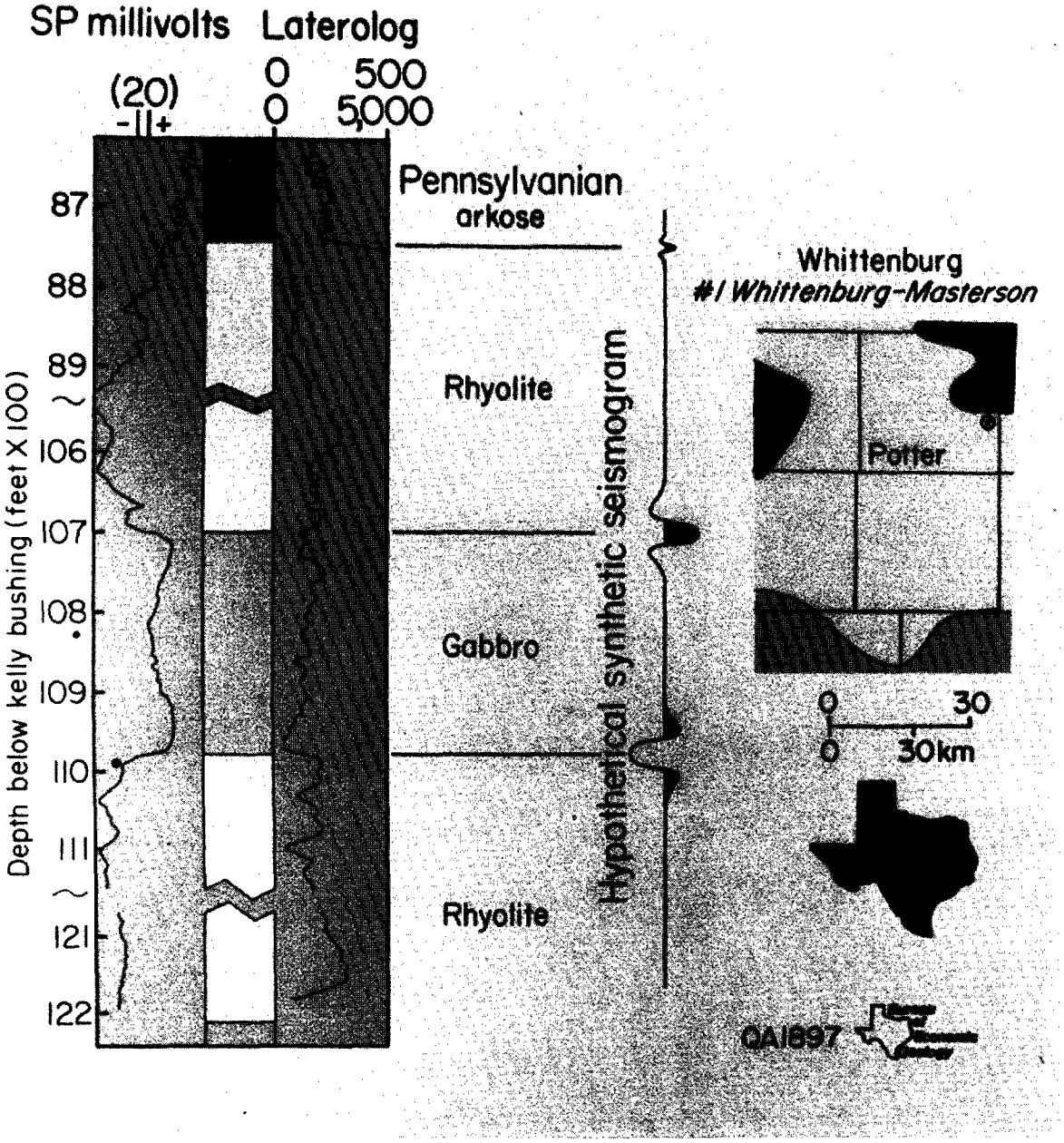

INDEX MAP
Oldham
NEW MEXICO
TEXAS
EROSIONAL
LIMIT OF
DOCKUM
Bailey
Floyd
1
2
3
4
5
6
7
1'
2'
3'
4'
5'
6'
7'
study area
OK
N.M.
TX
N
0
40mi
0
40km
Bureau of Economic Geology
QA4544
• Well control for cross sections
Composite cross section

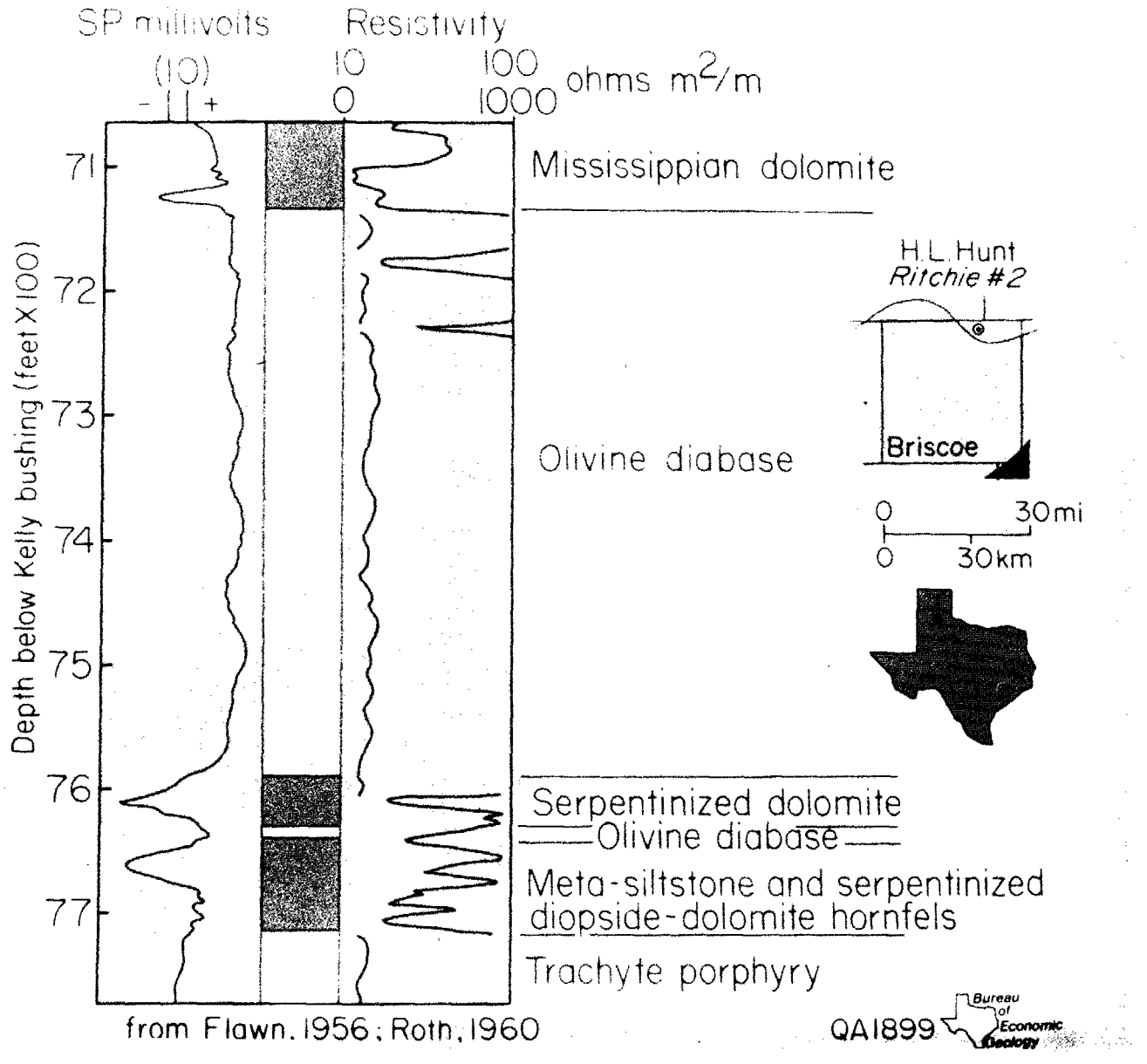

R
P
M
PC
DOLOMITE

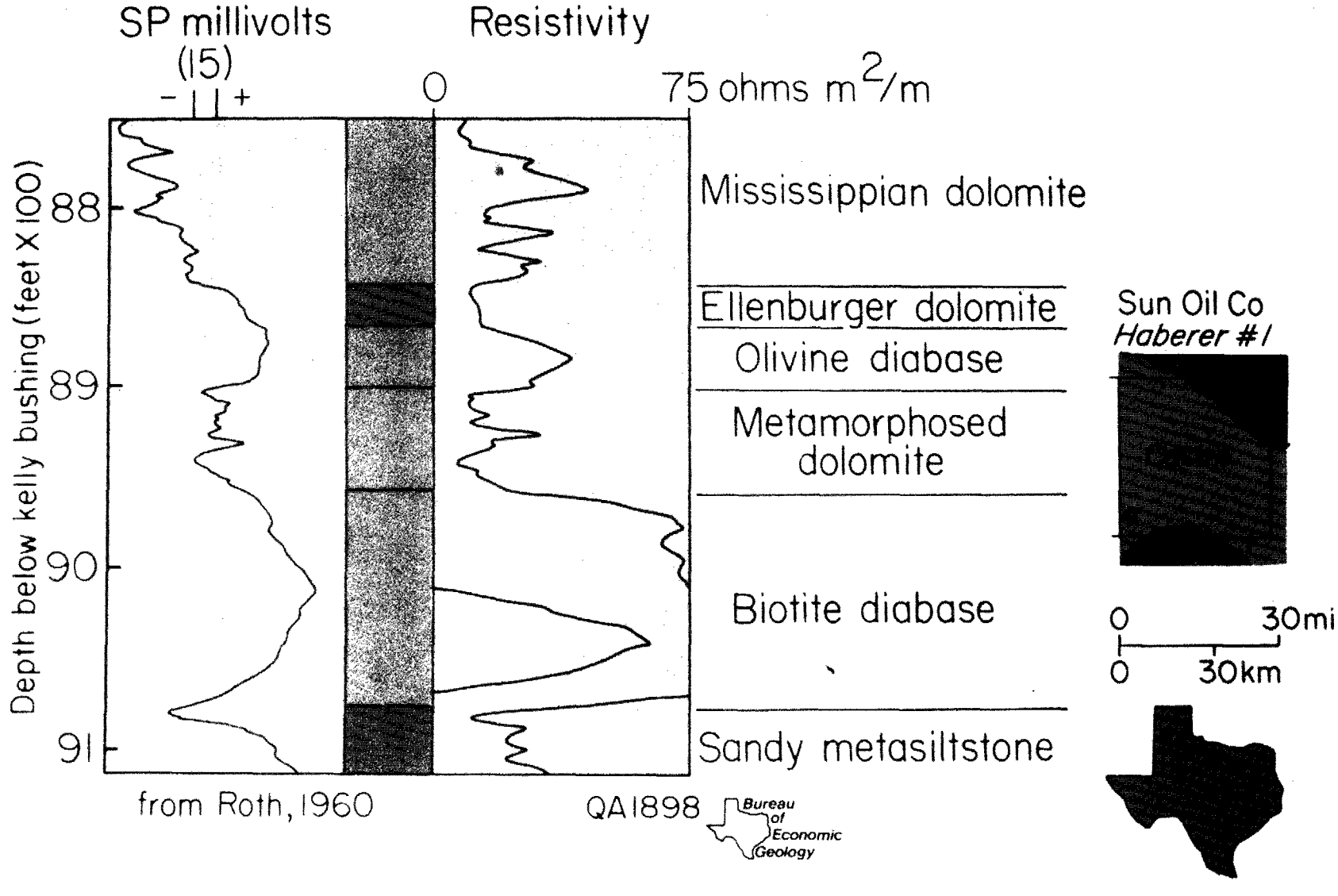


DISTRIBUTION OF BASEMENT TERRANES

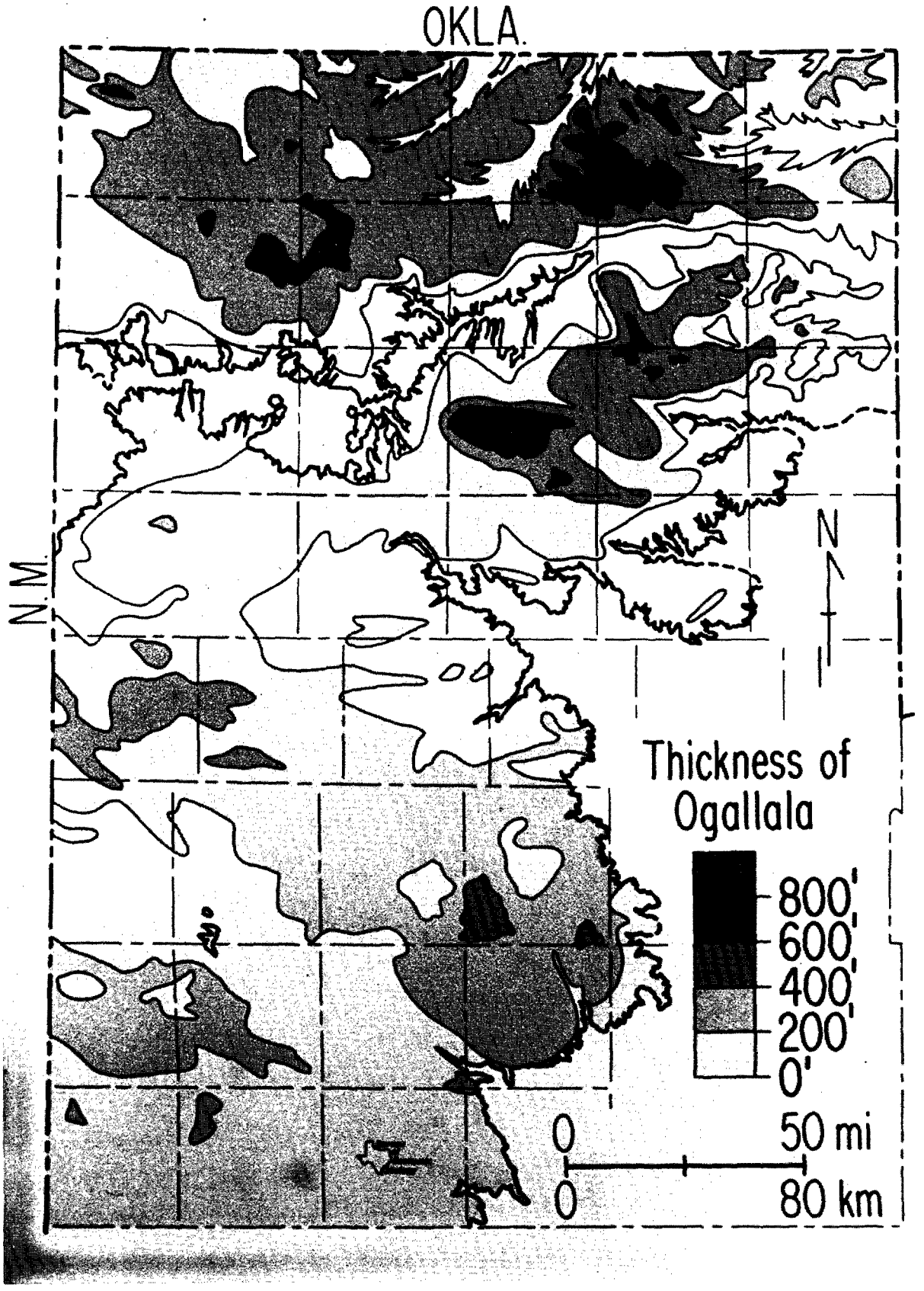

DISTRIBUTION OF SEISMIC LINES AND WELL CONTROL
Non-Proprietary seismic
Proprietary seismic
• Well control
from Flawn, 1956
Muehlburger
and others 1967
0 10 20mi
0 20km
QA1894
Oldham Co
Potter Co
Panhandle rhyolite
Deaf Smith Co
Randall Co
Armstrong Co
Briscoe Co
TEXAS
Parmer Co
Castro Co
Swisher Co
Swisher diabase


SP millivolts
Laterolog
(20)
-11+
0
500
0
5,000
Depth below kelly bushing (feet X 100)
87
88
89
106
107
108
109
110
111
121
122
Pennsylvanian
arkose
Rhyolite
Gabbro
Rhyolite
Hypothetical synthetic seismogram
Whittenburg
#1 Whittenburg-Masterson
Potter
0
30
0
30km
OA1897

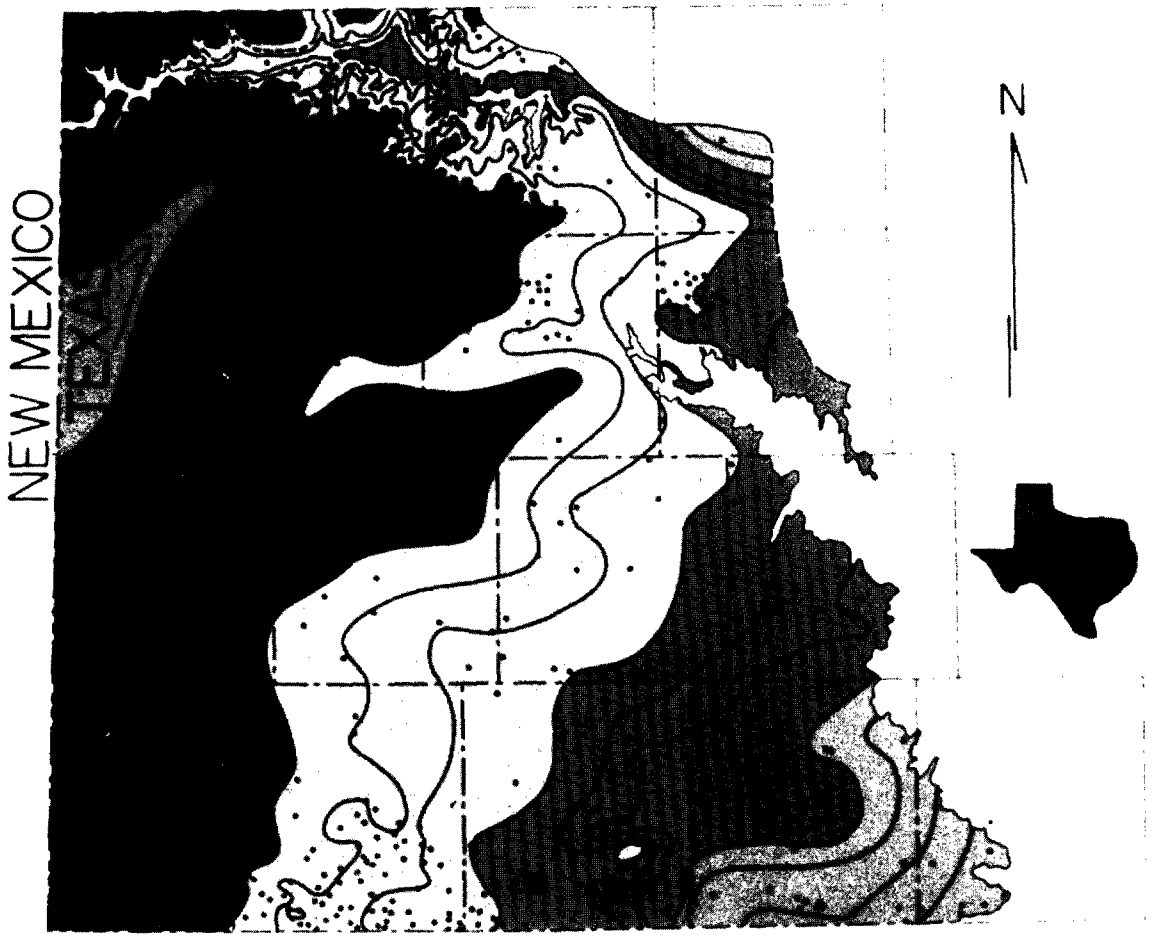

SP millivolts
(10)
- +
Resistivity
10
0
100
1000
ohms m²/m
Depth below Kelly bushing (feet X 100)
71
72
73
74
75
76
77
Mississippian dolomite
Olivine diabase
Serpentinized dolomite
Olivine diabase
Meta-siltstone and serpentinized diopside-dolomite hornfels
Trachyte porphyry
H.L. Hunt
Ritchie #2
Briscoe
0
30mi
0
30km
from Flawn, 1956; Roth, 1960
QA1899
Bureau of Economic Geology


SP millivolts
(15)
- +
Resistivity
0
75 ohms m²/m
Depth below kelly bushing (feet X 100)
88
89
90
91
Mississippian dolomite
Ellenburger dolomite
Olivine diabase
Metamorphosed dolomite
Biotite diabase
Sandy metasiltstone
from Roth, 1960
QA1898
Bureau of Economic Geology
Sun Oil Co
Haberer #1
0
30mi
0
30km

GRAVITY REGIONAL ANOMALIES


OKLA.
N.M.
N
Thickness of
Ogallala
800'
600'
400'
200'
0'
0
50 mi
0
80 km

STRUCTURE CONTOUR
TOP OF DOCKUM GROUP



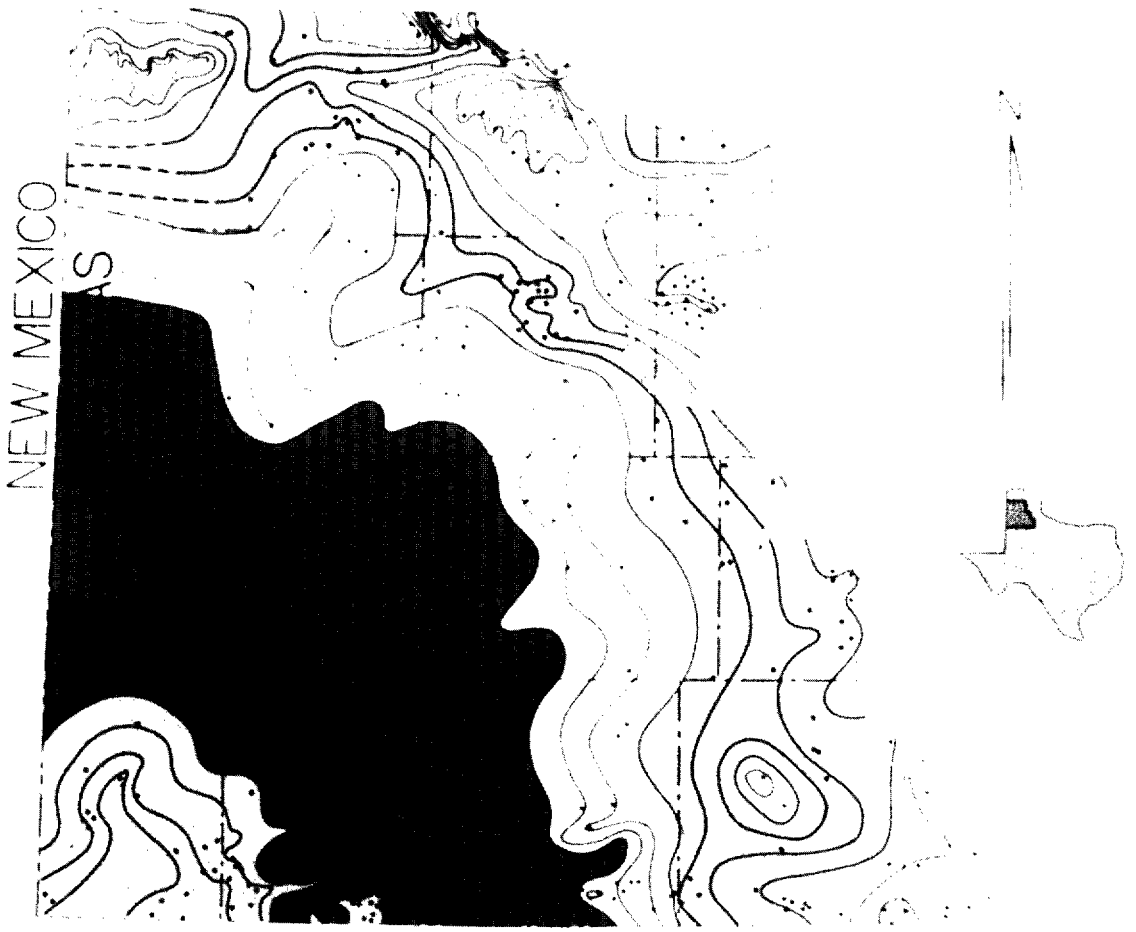
< 2900ft
2900-3200
3200-3500
3500-3800
3800-4100
> 4100

0 40mi
0 40km

Contour interval = 100ft

QA-1907

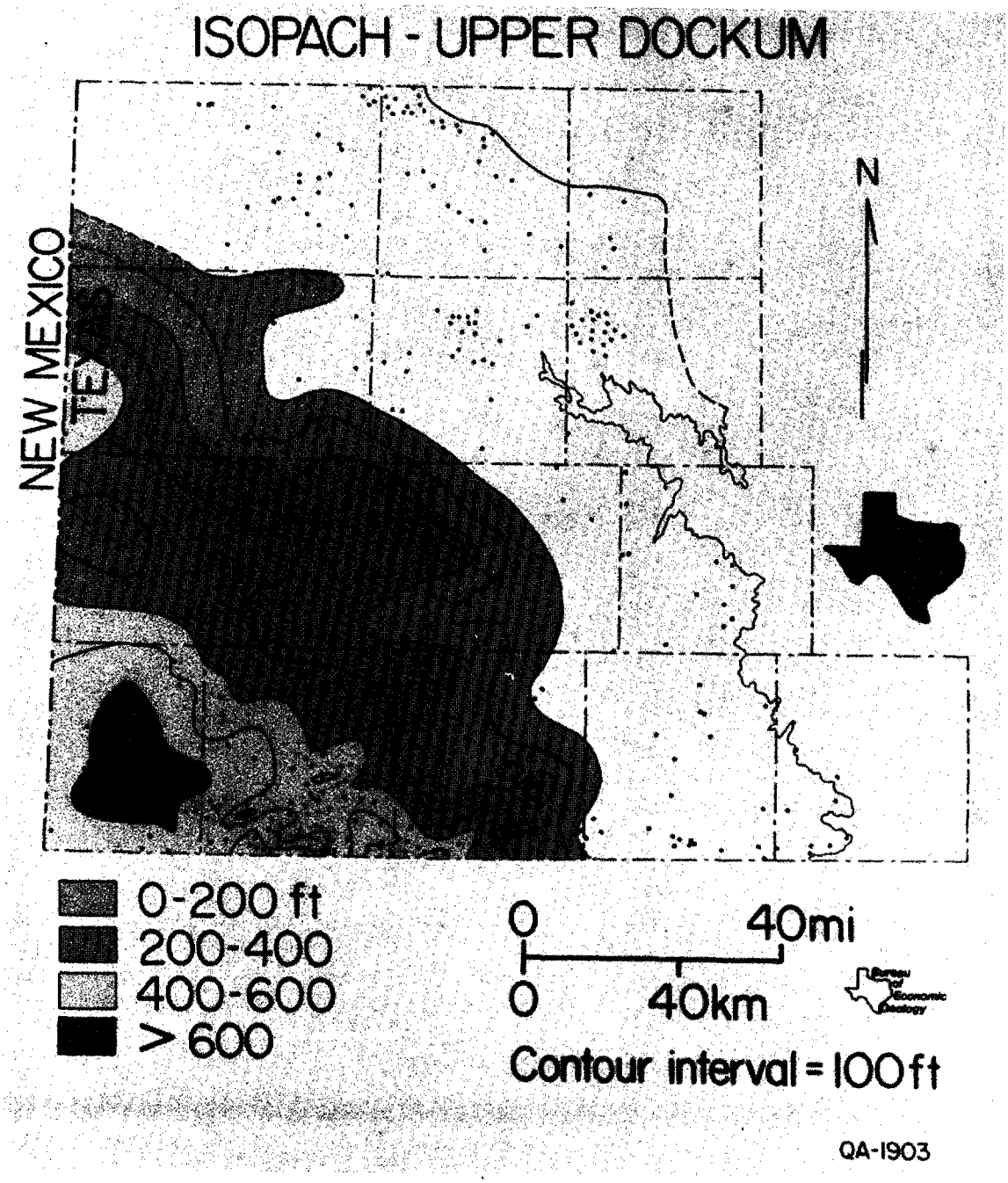
ISOPACH - DOCKUM GROUP



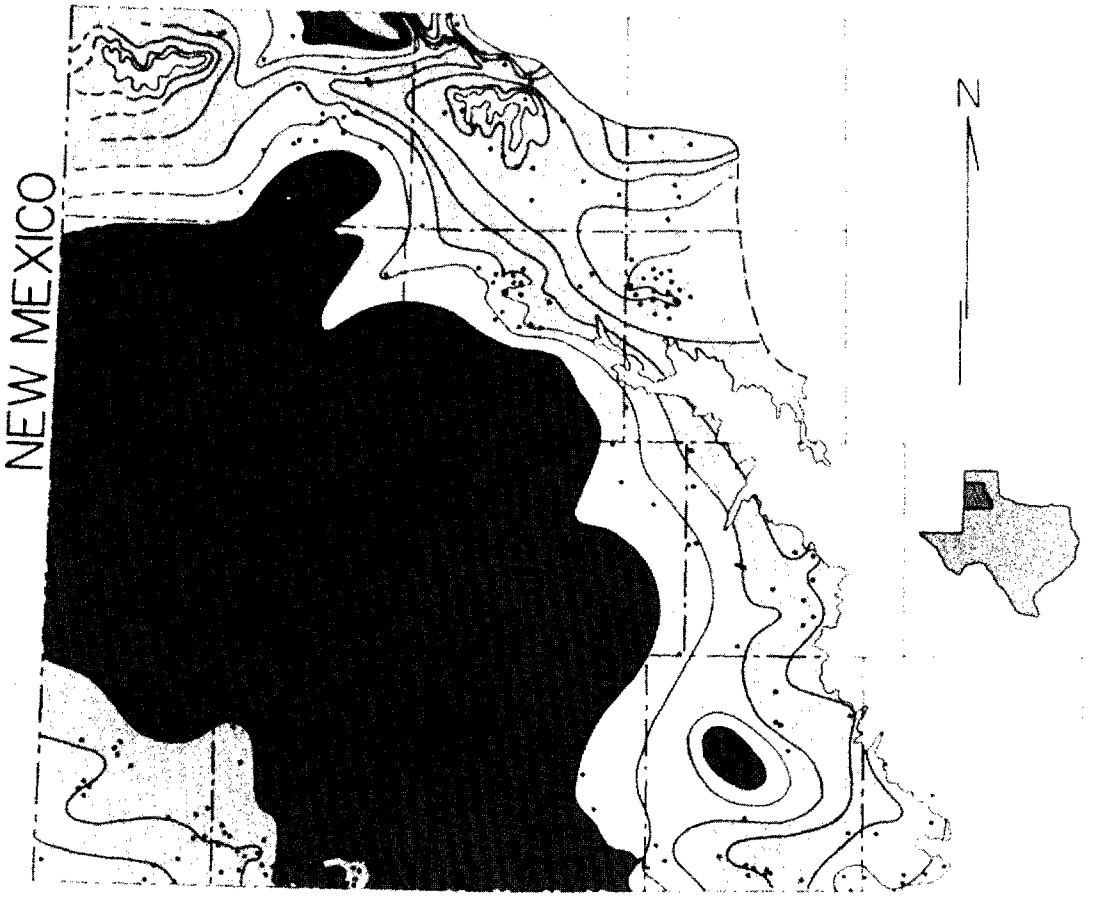
0-300 ft
300-600
600-900
900-1200
1200-1500
>1500

0 40mi
0 40km

Contour interval = 100ft


ISOPACH - UPPER DOCKUM
NEW MEXICO
TE
N
0-200 ft
200-400
400-600
> 600
0
40mi
0
40km
Contour interval = 100 ft
QA-1903

ISOPACH - LOWER DOCKUM

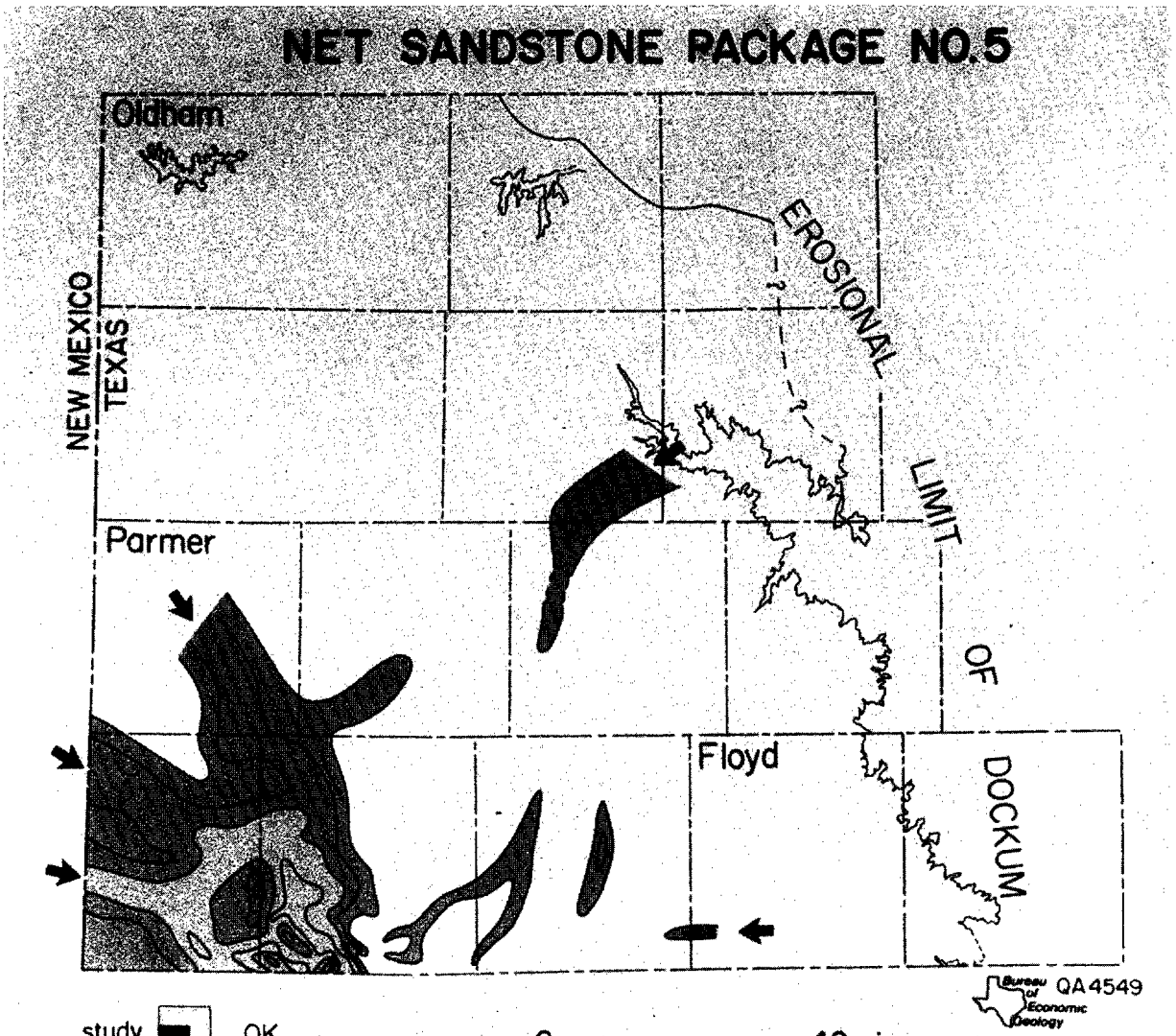


0-200 ft
200-400
400-600
600-800
800-1000
1000-12000
> 1200

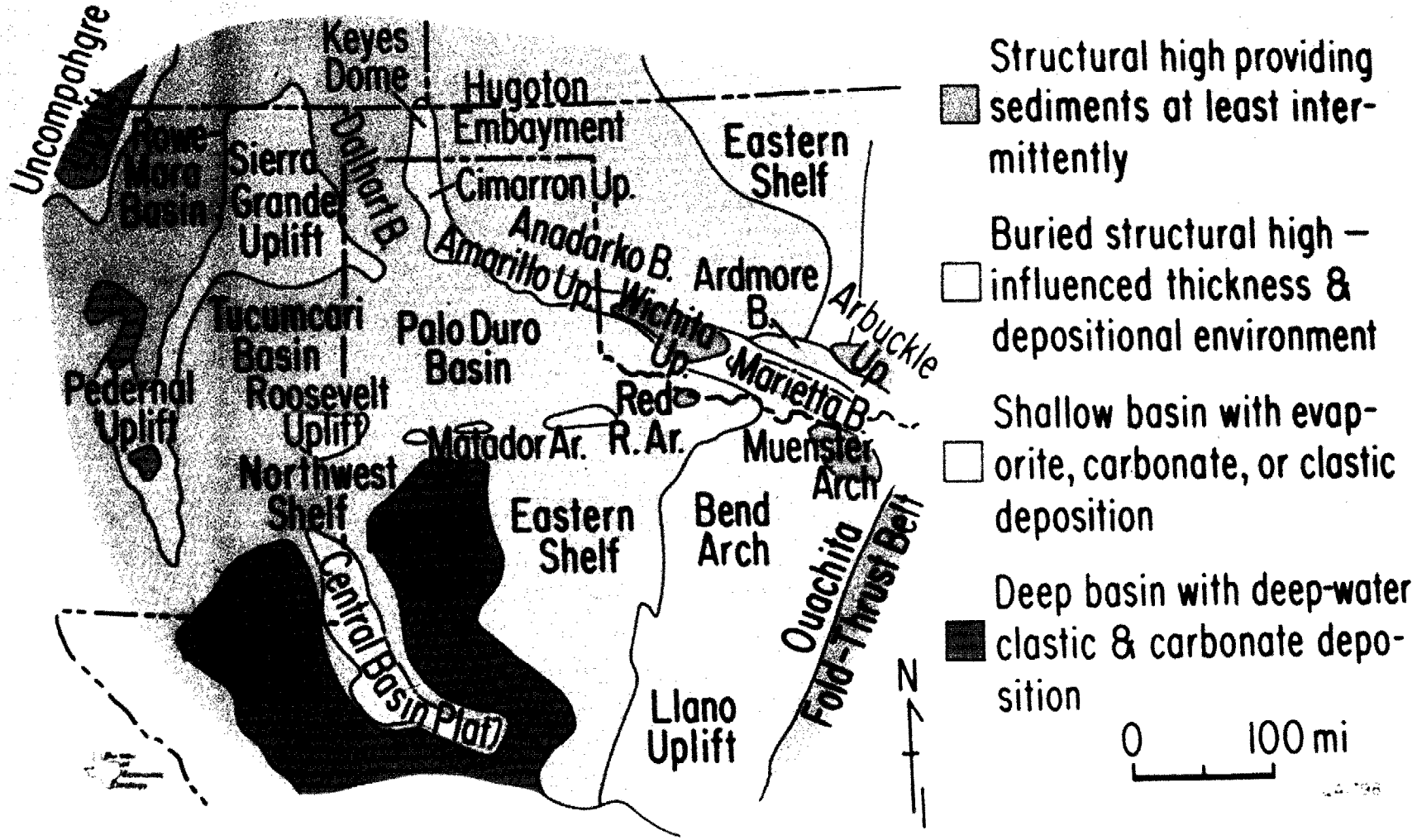
0 40mi
0 40km

Contour interval = 100'

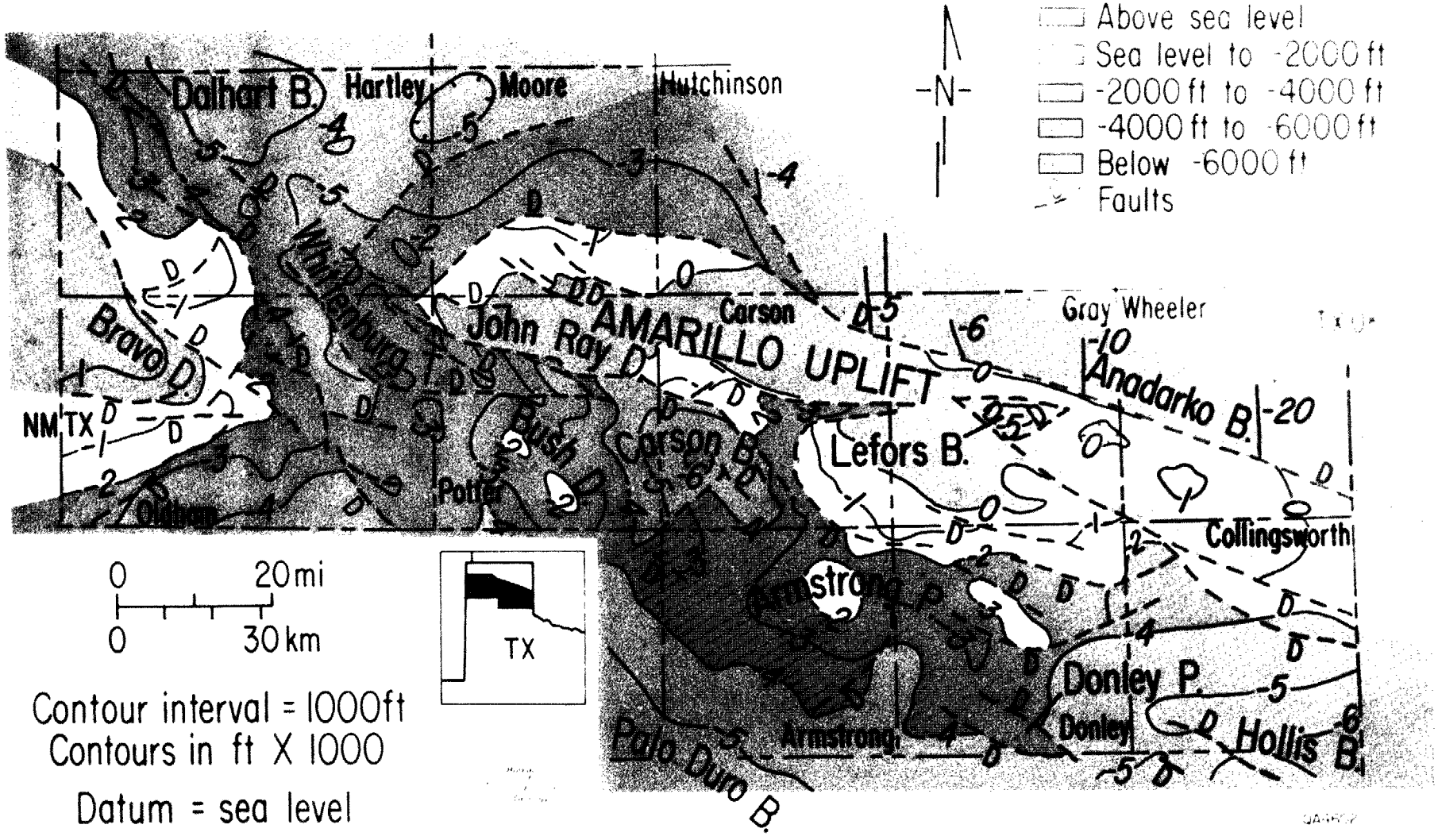
QA-1905


NET SANDSTONE PACKAGE NO.5
Oldham
NEW MEXICO
TEXAS
EROSIONAL
LIMIT
OF
DOCKUM
Parmer
Floyd
QA4549
Bureau of Economic Geology
study area
OK
N.M.
TX
-N-
0
40mi
0
40km
contour interval = 20ft
EXPLANATION
0-20
20-60
60-100
>100

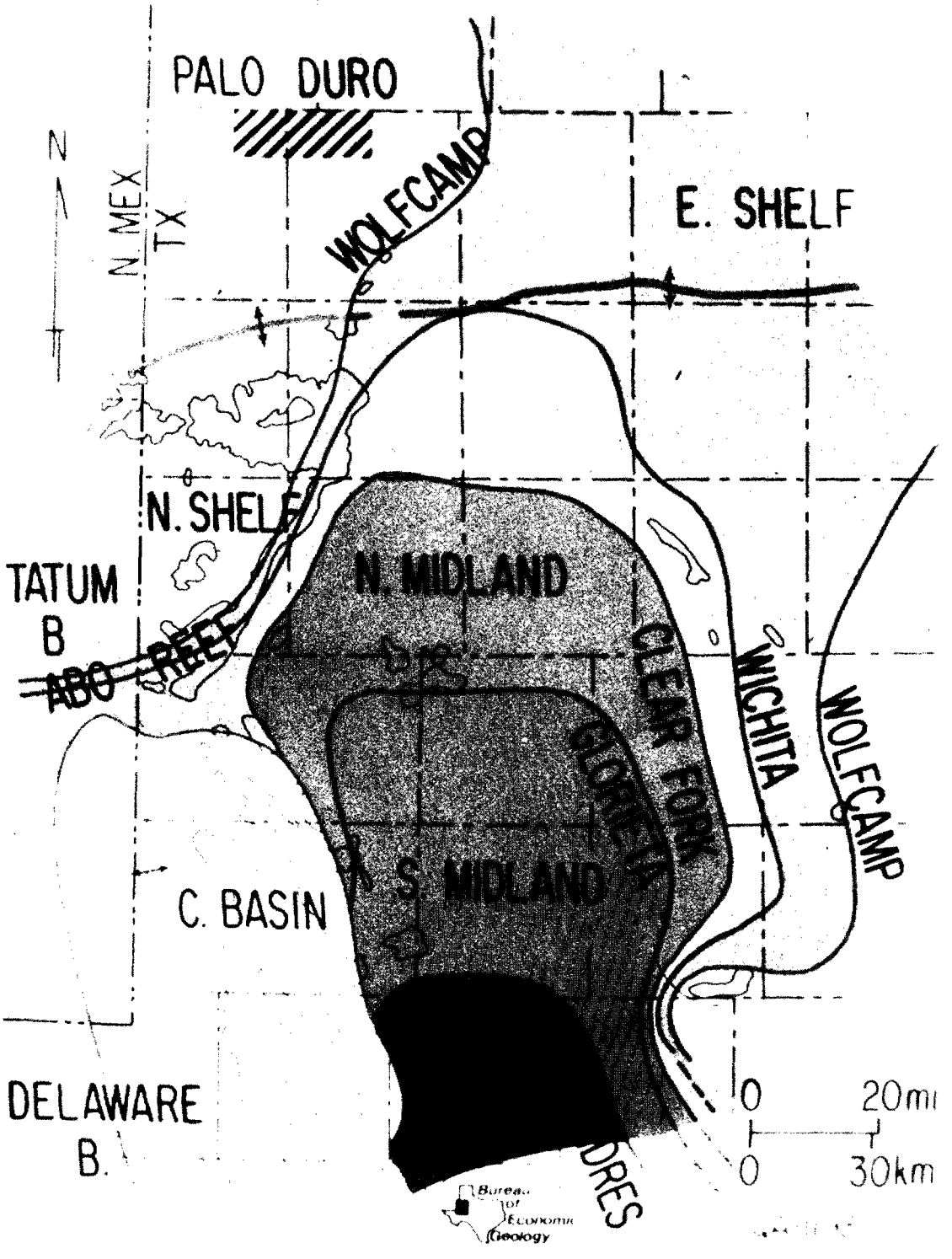
MIDDLE & LATE PERMIAN TECTONIC ELEMENTS



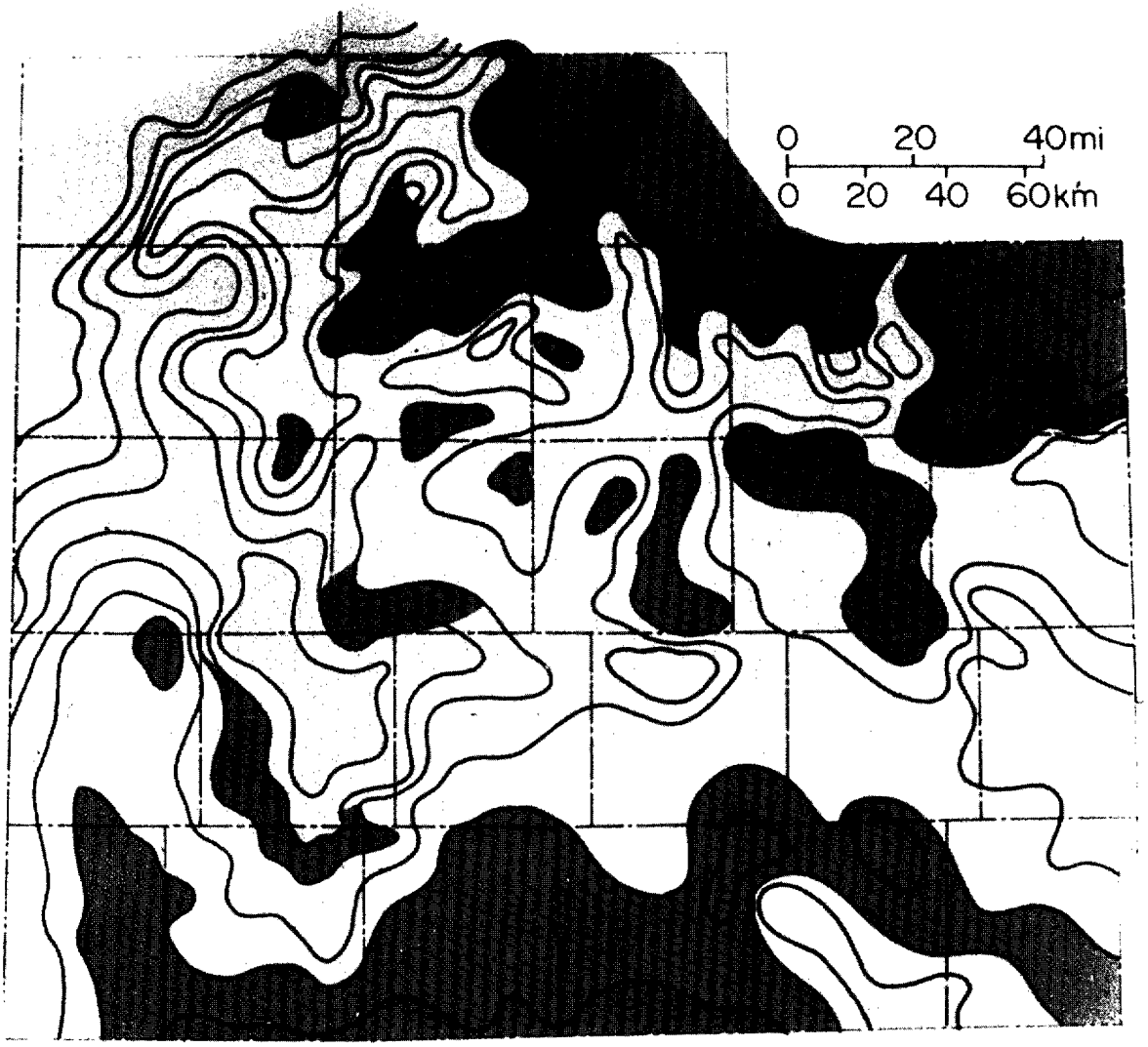
Basement structure map of Amarillo Uplift



PROGRADATION OF PERMIAN SHELF MARGIN SOUTHERN TEXAS PANHANDLE

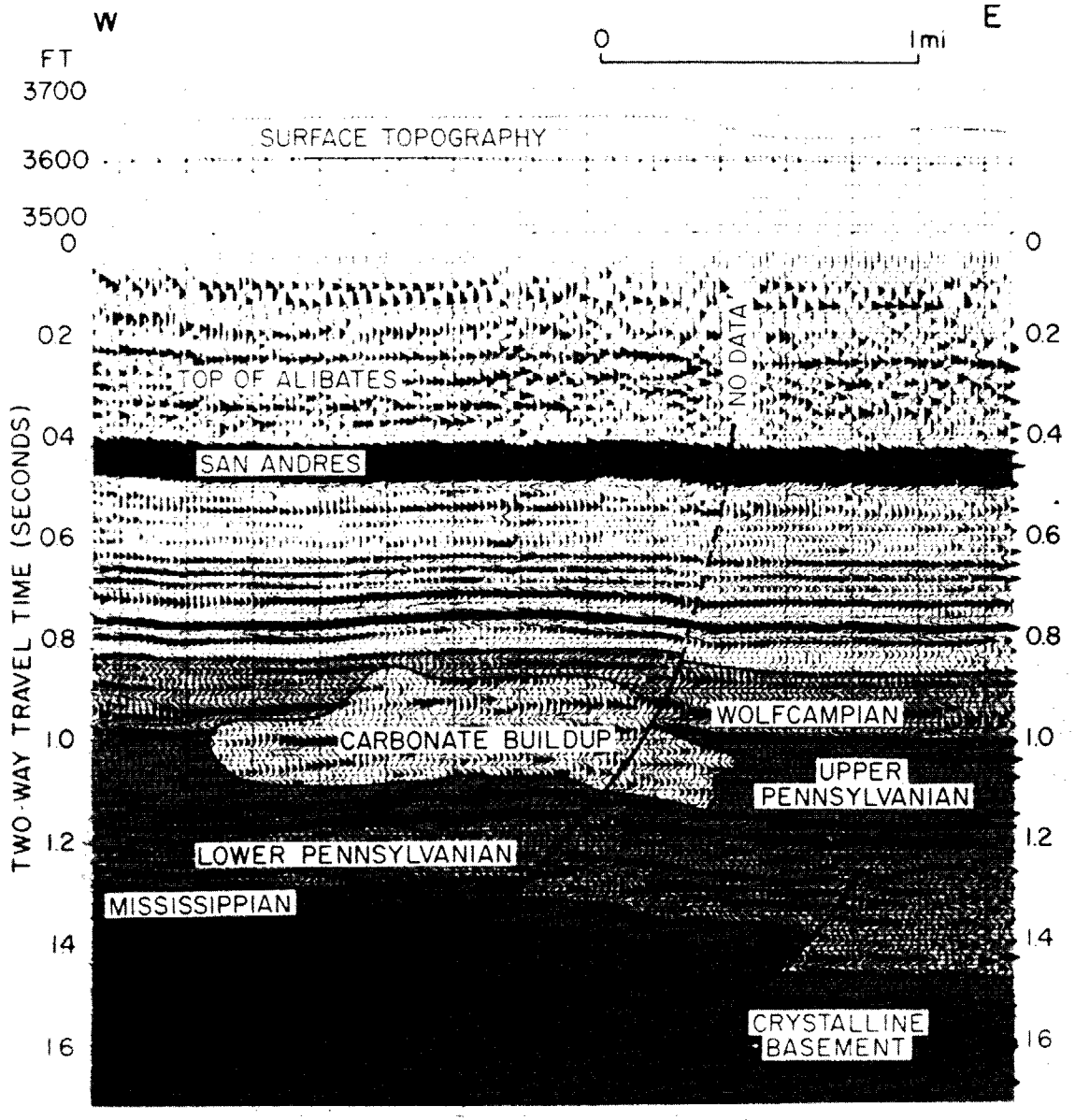


GENERALIZED LITHOFACIES - WICHITA GROUP

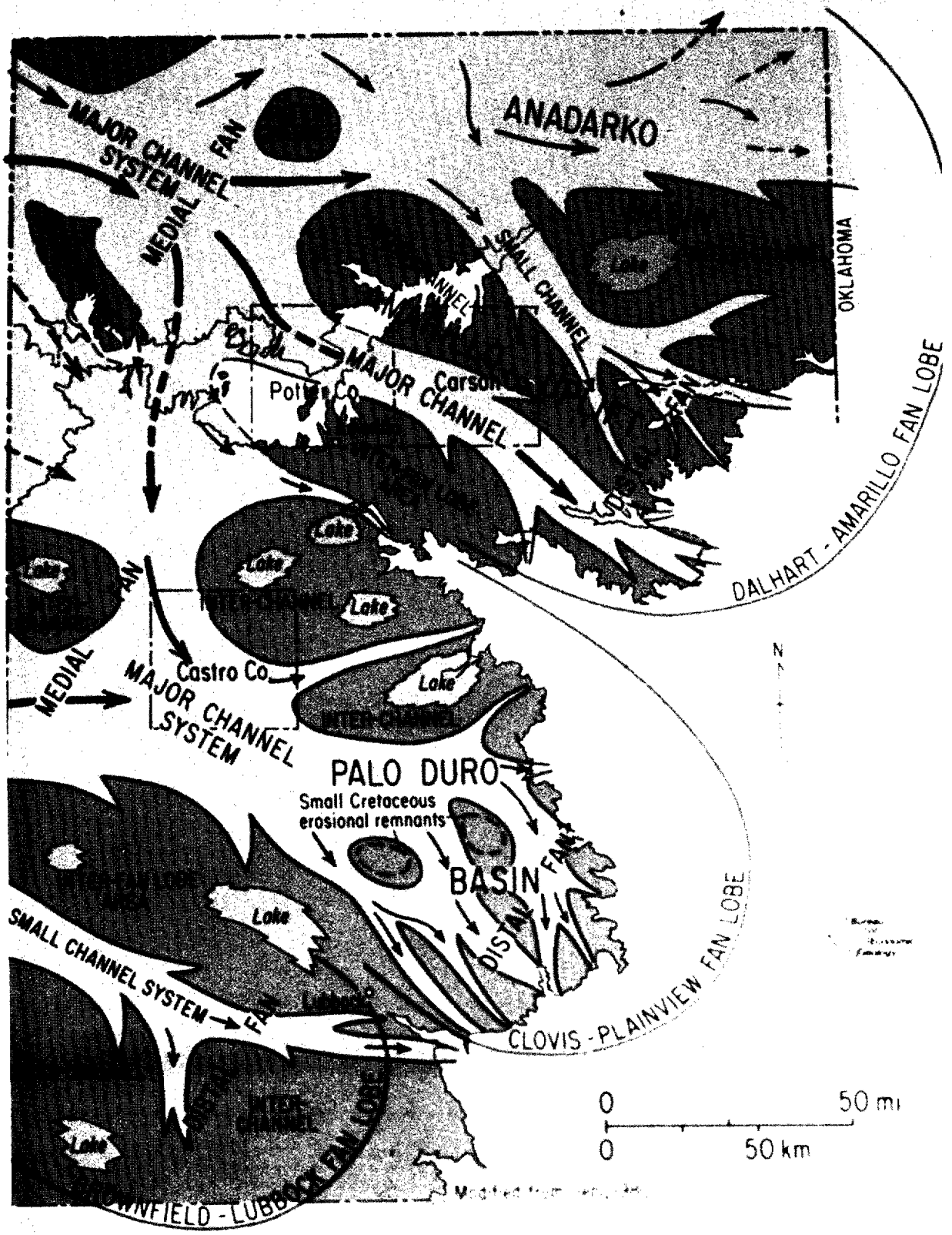


>80% CARB
>60% CARB
40-60% CARB ANHY > CLASTICS
40-60% CARB CLASTICS > ANHY
<40% CARB ANHY > CLASTICS
<40% CARB CLASTICS > ANHY

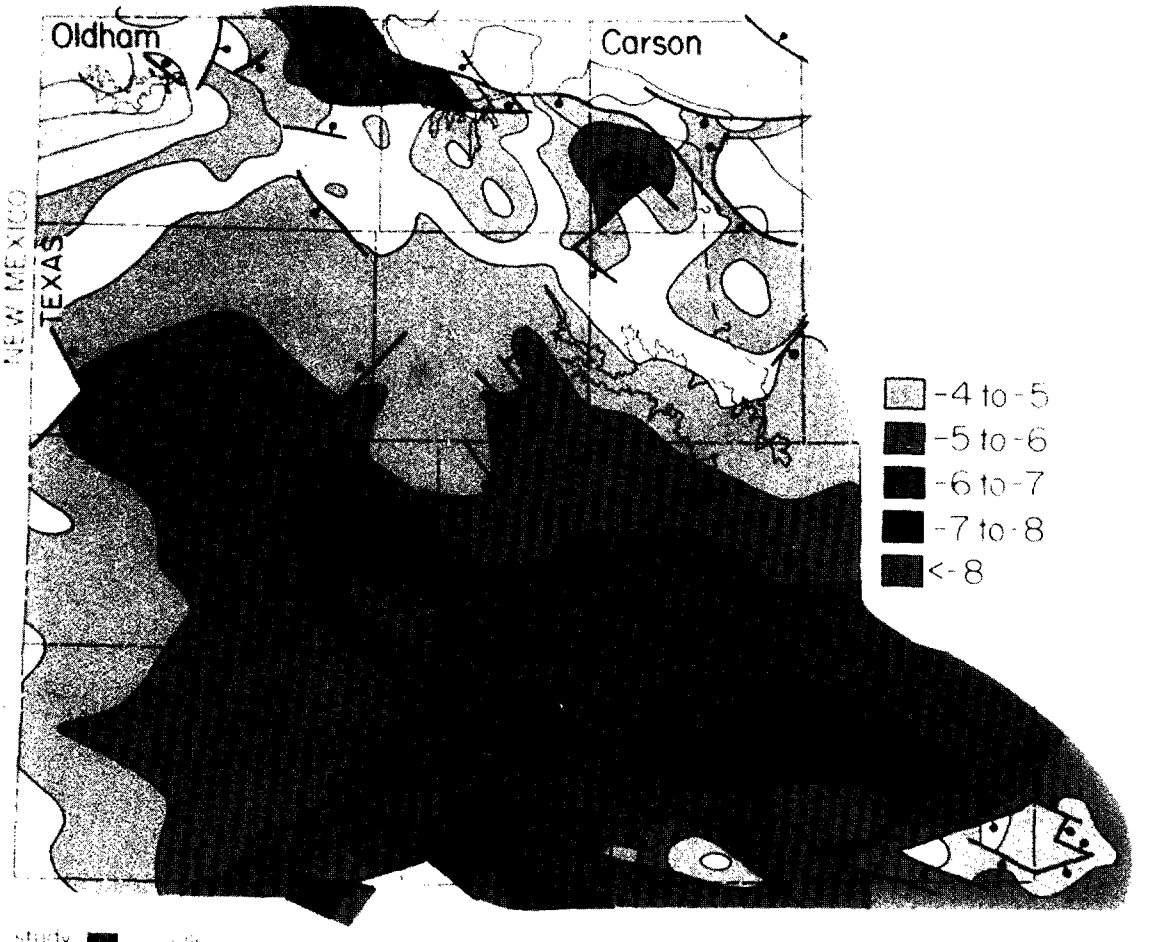
%CARB (=DOLOMITE)
CI = 10%


W
E
0
1 mi
FT
3700
3600
3500
0
SURFACE TOPOGRAPHY
TWO-WAY TRAVEL TIME (SECONDS)
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
TOP OF ALIBATES
NO DATA
SAN ANDRES
WOLFCAMPIAN
CARBONATE BUILDUP
UPPER PENNSYLVANIAN
LOWER PENNSYLVANIAN
MISSISSIPPIAN
CRYSTALLINE BASEMENT

DEPOSITIONAL PATTERNS OF OGALLALA FM



SIMPLIFIED BASEMENT STRUCTURE

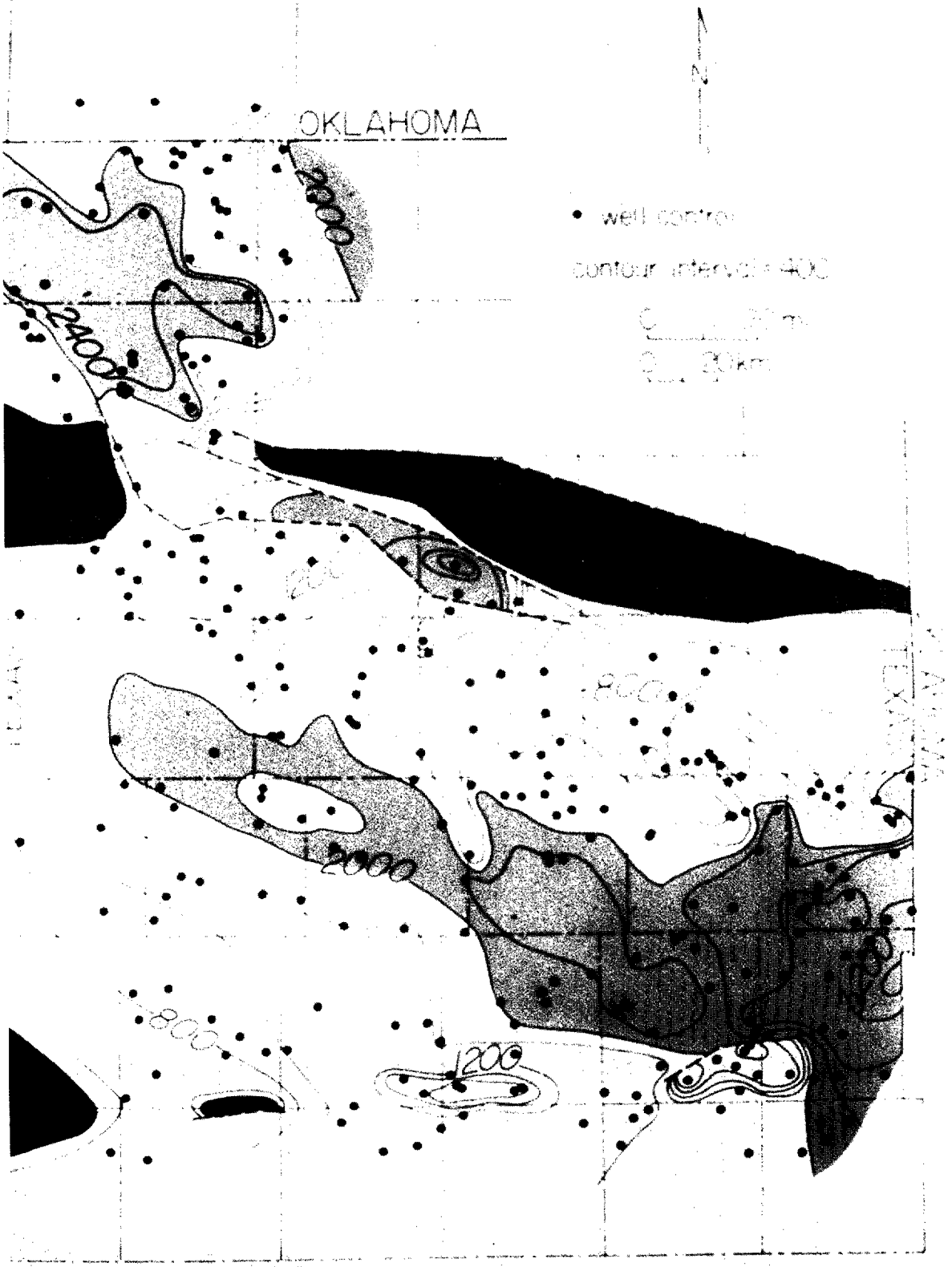


EXPLANATION

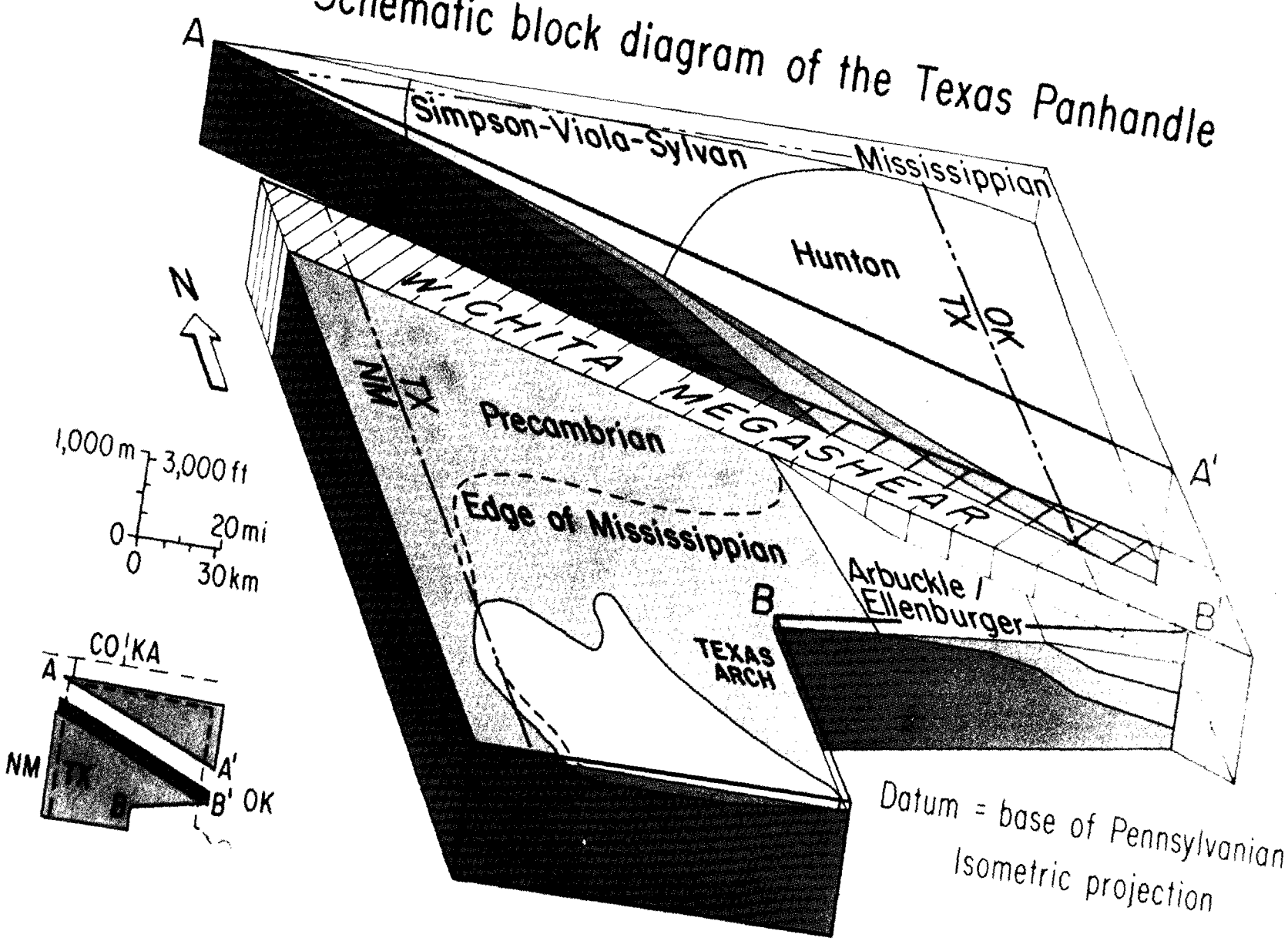
(from Budnik, 1984)

0 to -1
-1 to -2
-2 to -3
-3 to -4

THICKNESS OF PENNSYLVANIAN

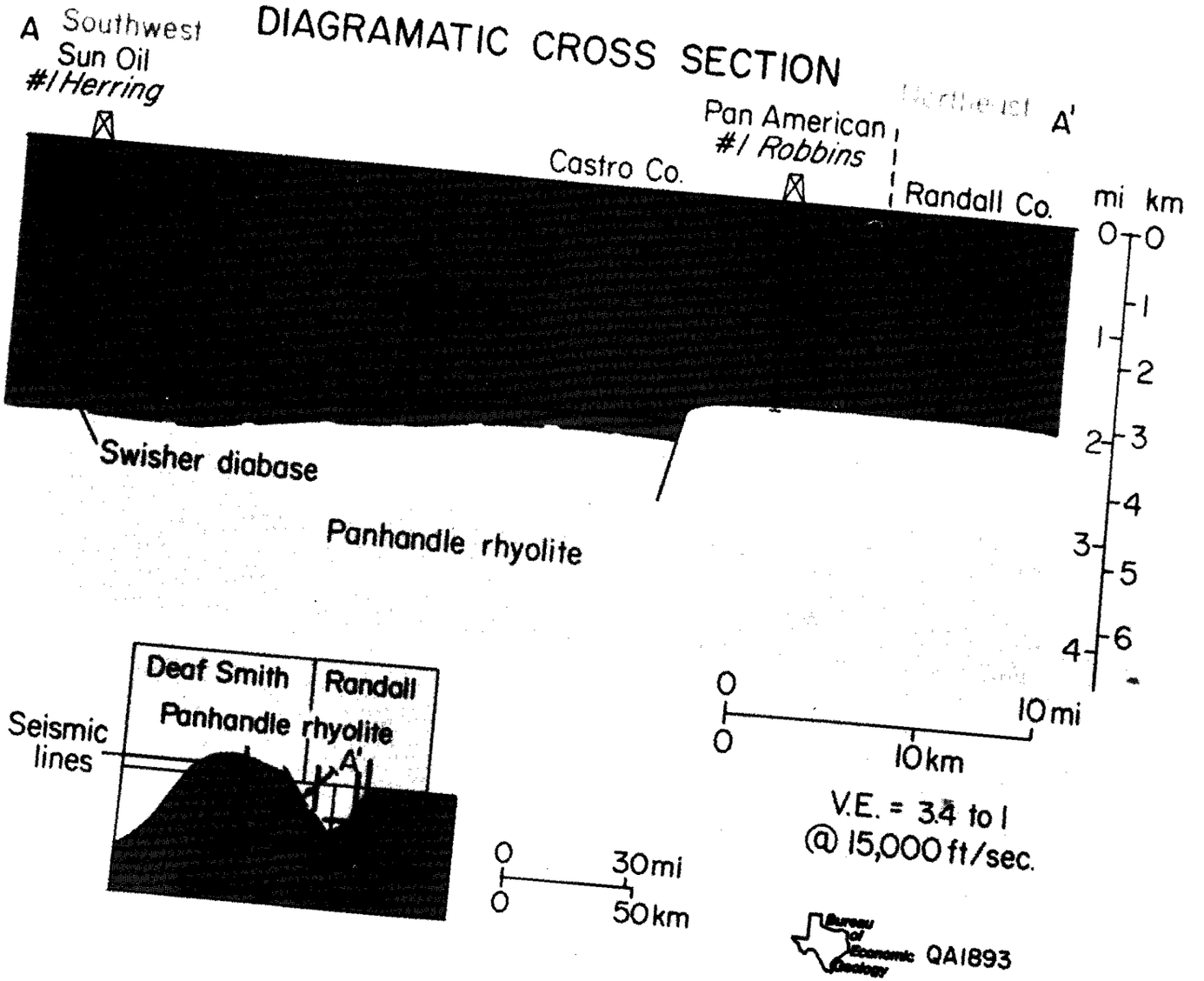


Schematic block diagram of the Texas Panhandle

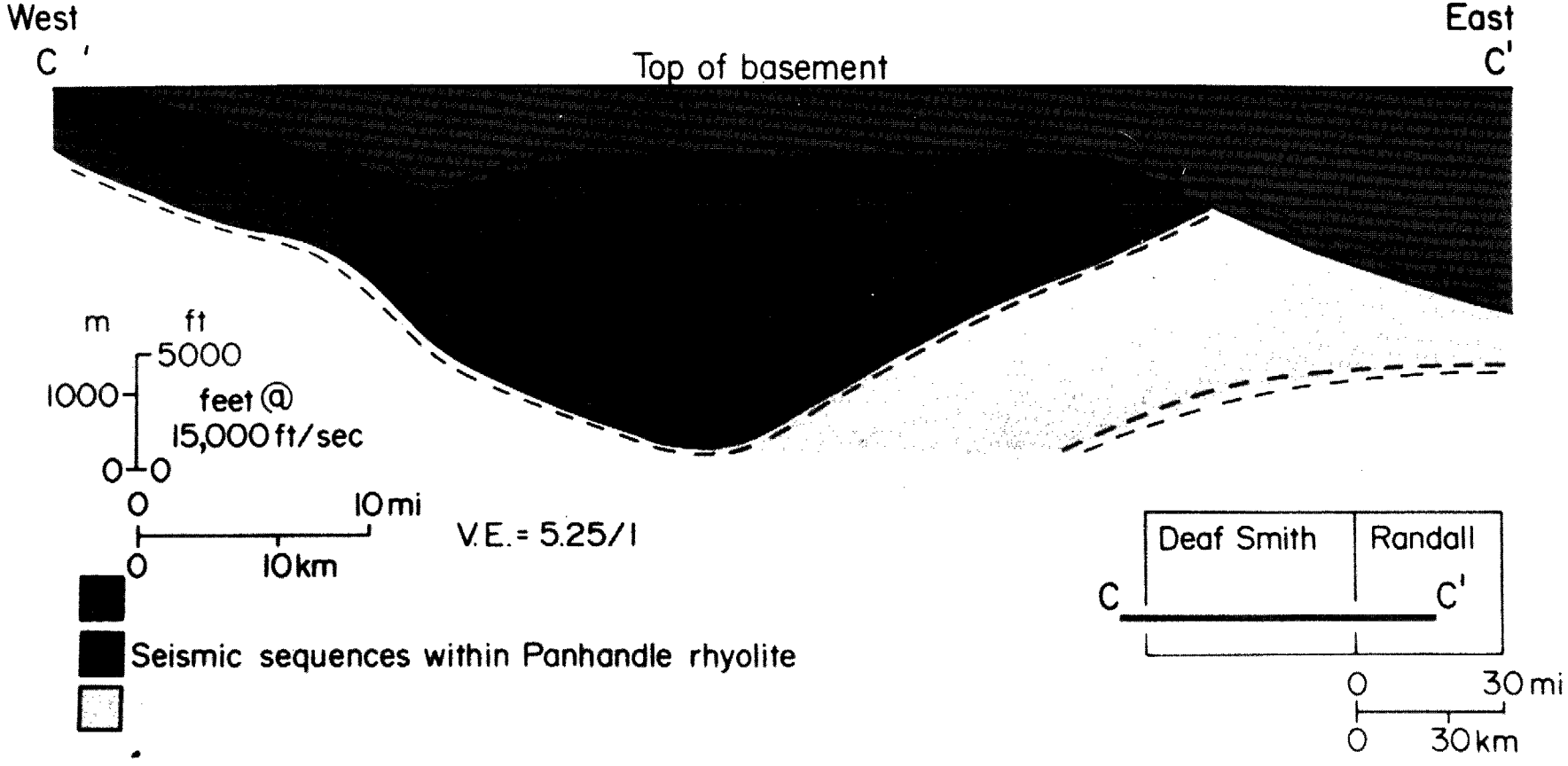


Datum = base of Pennsylvanian

Isometric projection


A Southwest
Sun Oil
#1 Herring
DIAGRAMATIC CROSS SECTION
Pan American
#1 Robbins
Northeast A'
Castro Co.
Randall Co.
mi km
0 0
1 1
2 2
3 3
4 4
5
6
Swisher diabase
Panhandle rhyolite
Deaf Smith
Randall
Panhandle rhyolite
Seismic lines
A'
0 10 mi
0 10 km
V.E. = 3.4 to 1
@ 15,000 ft/sec.
0 30 mi
0 50 km
QA1893

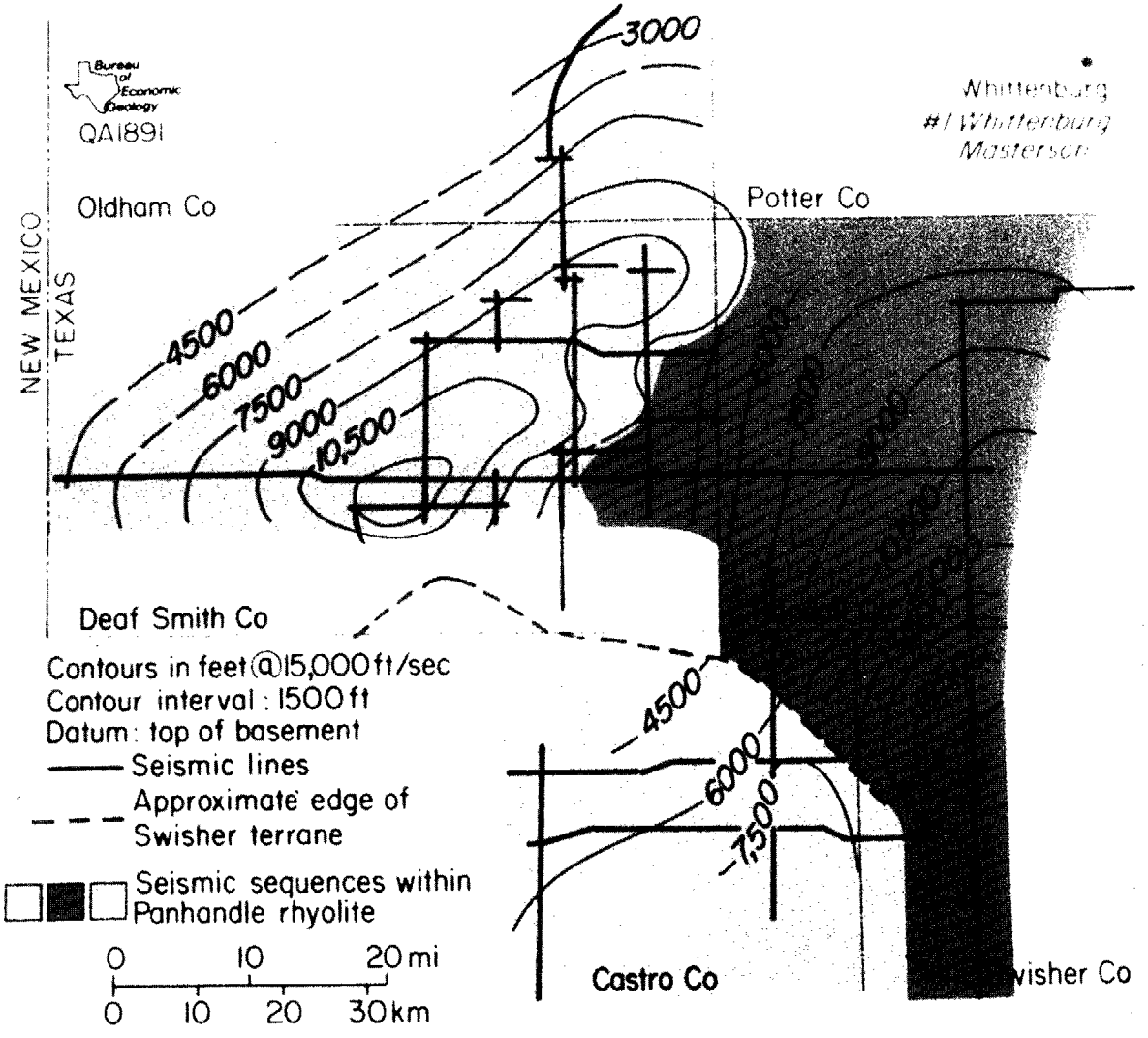
SEISMIC-DERIVED CROSS-SECTION



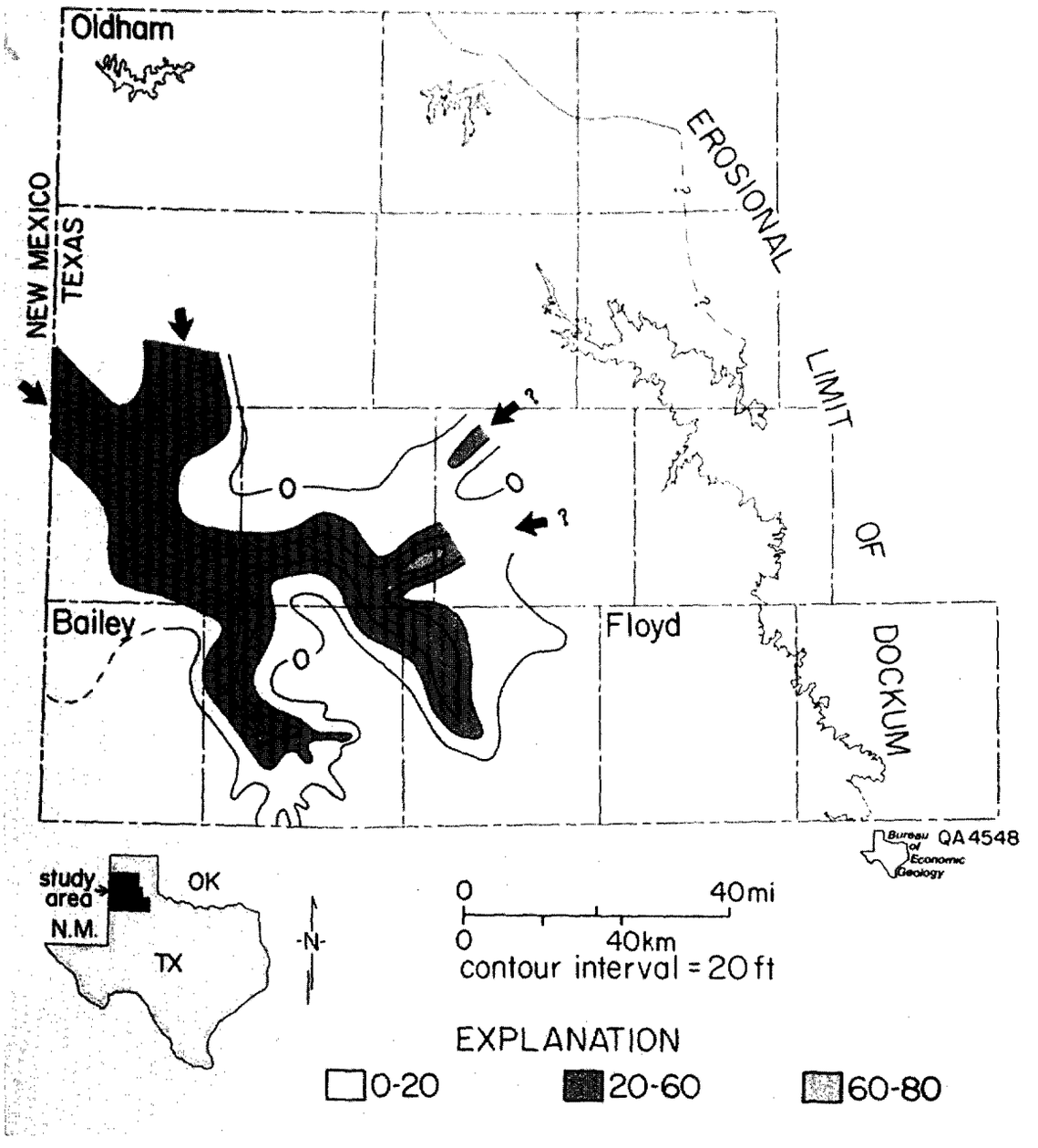
Bureau of Economic Geology

QA1895

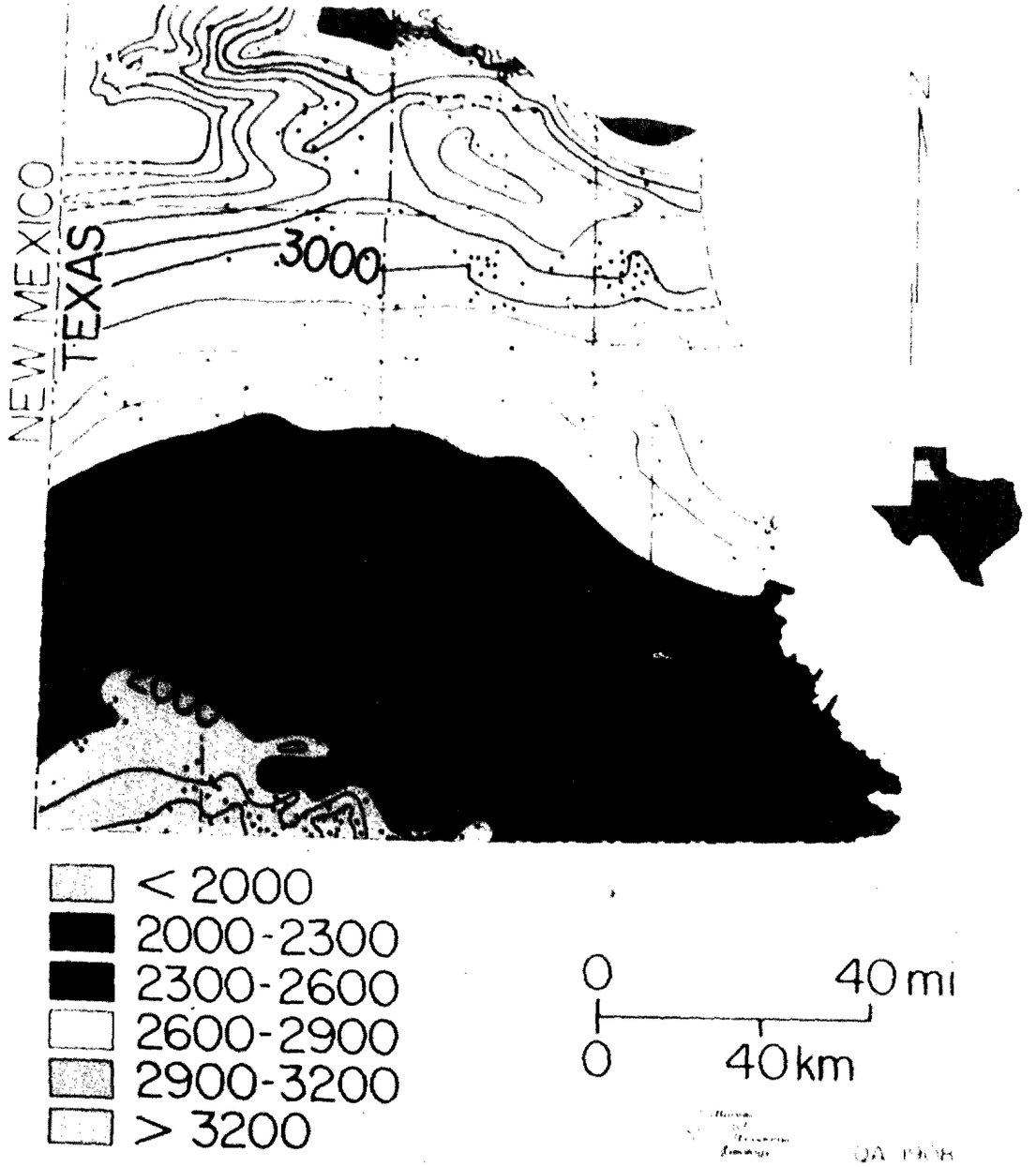
STRUCTURE ON BASE OF SEISMIC SEQUENCES



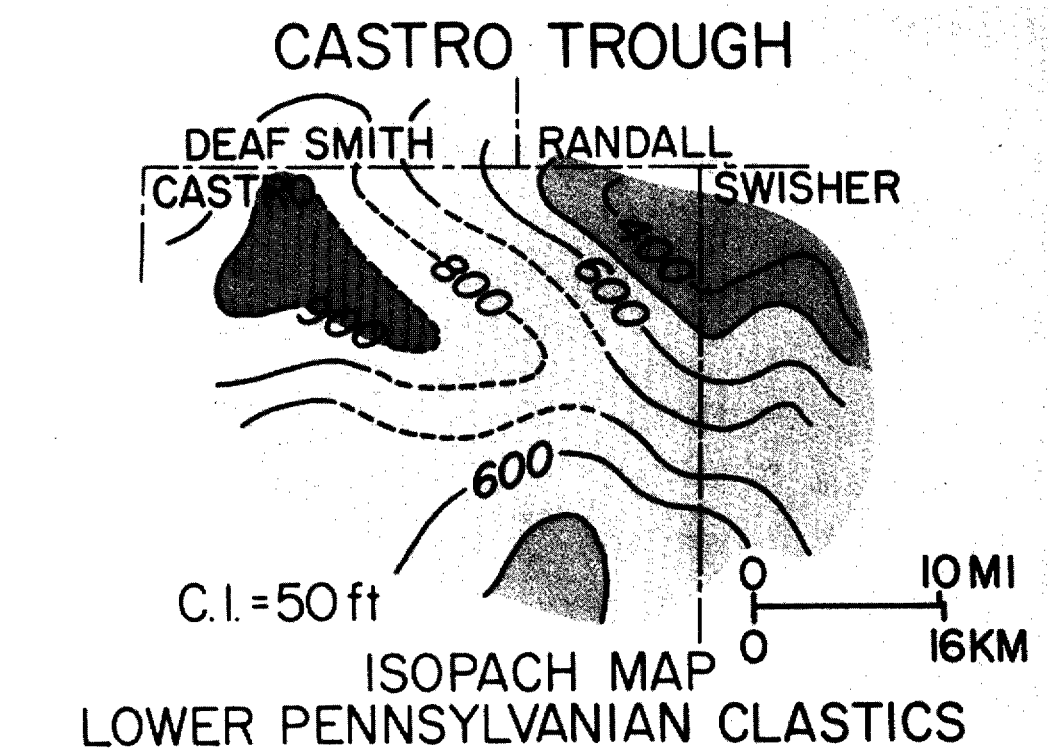
NET SANDSTONE PACKAGE NO. 4



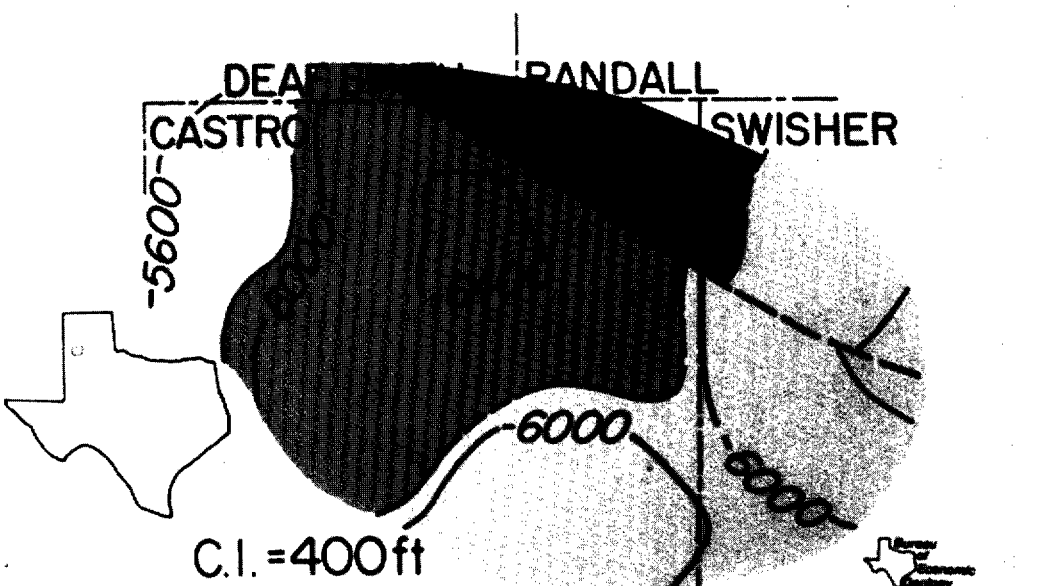
STRUCTURE CONTOUR
BASE OF DOCKUM GROUP



Contour interval = 100 ft



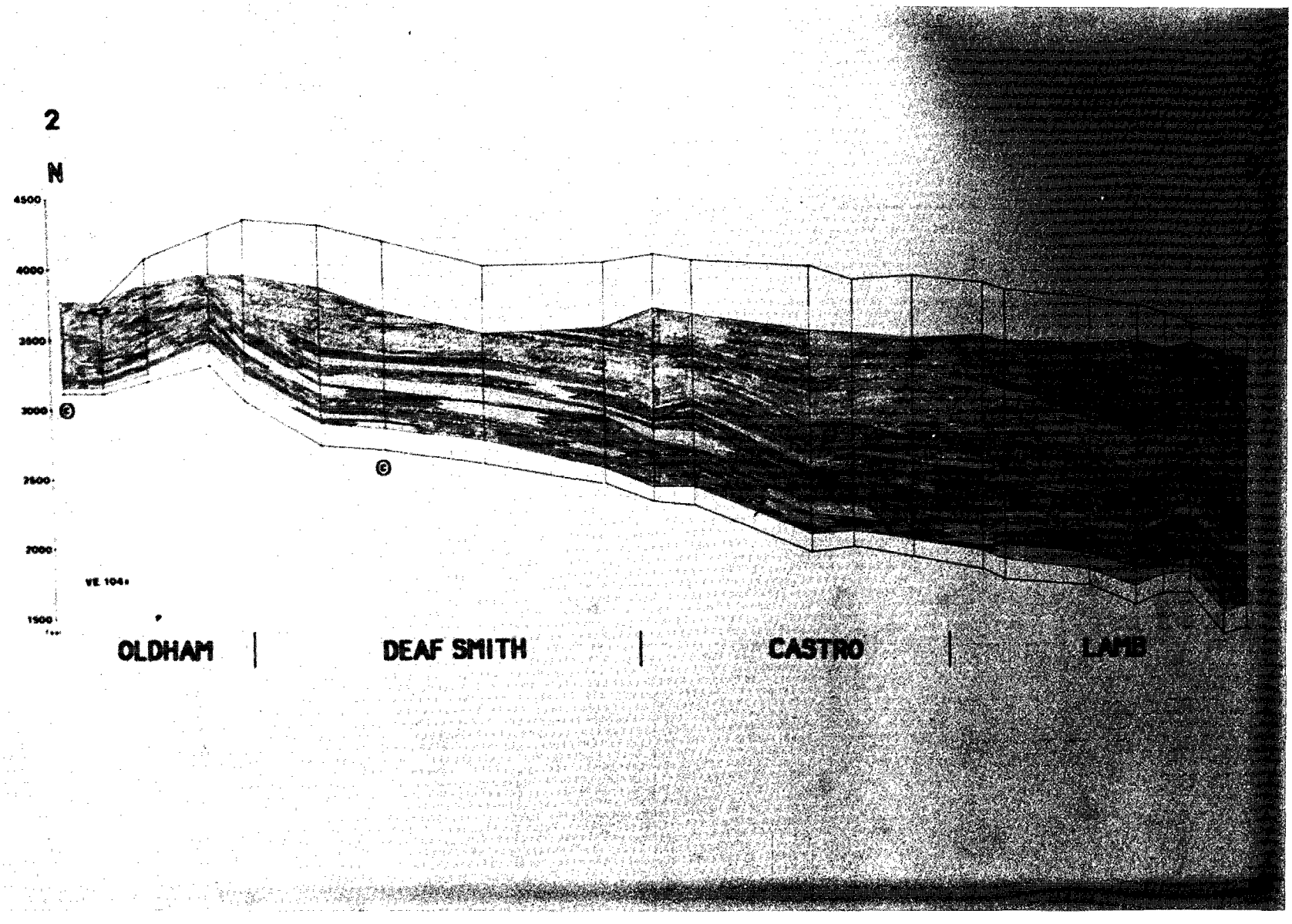
ISOPACH MAP
LOWER PENNSYLVANIAN CLASTICS

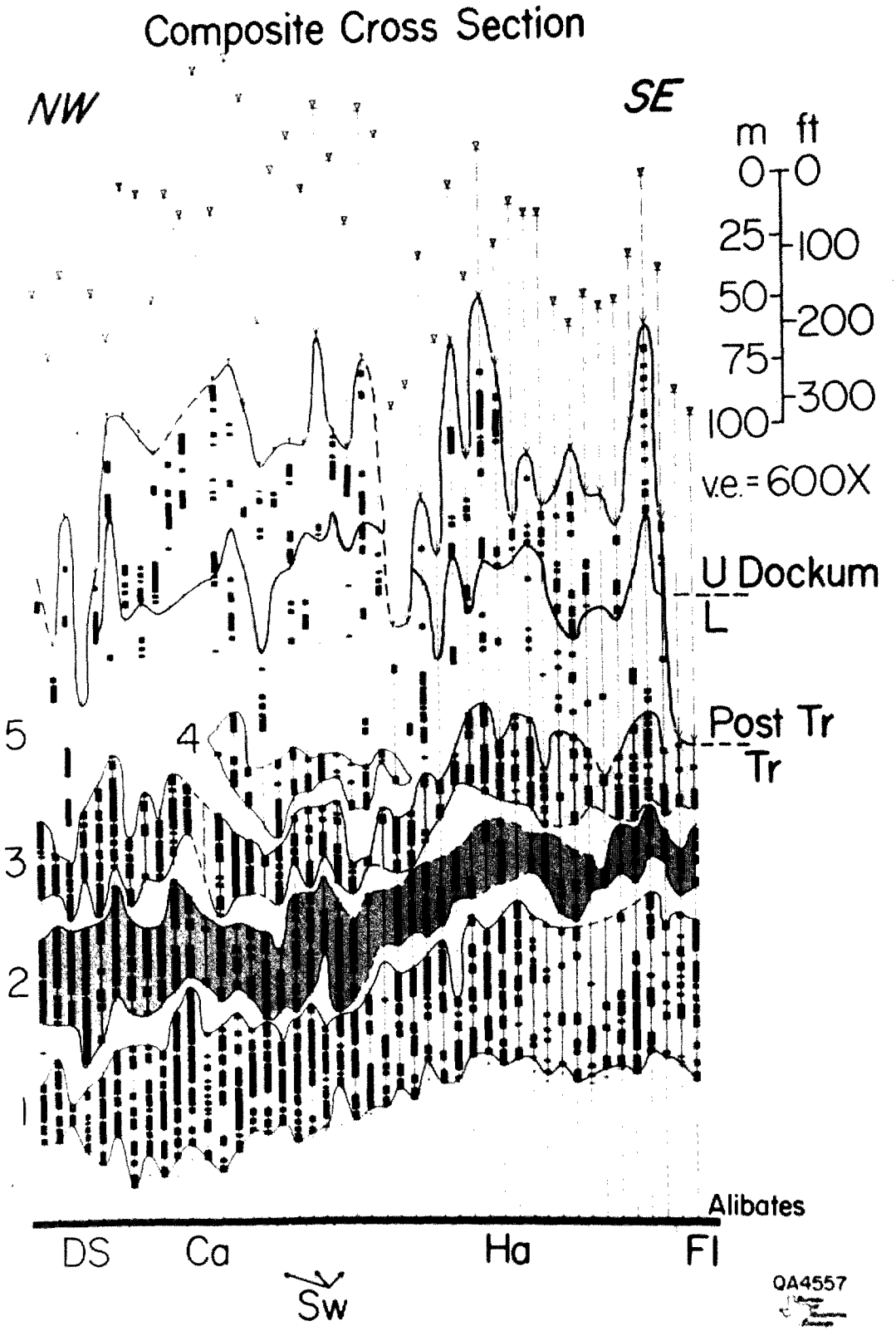


MISSISSIPPIAN SUBCROP
AND BASEMENT STRUCTURE

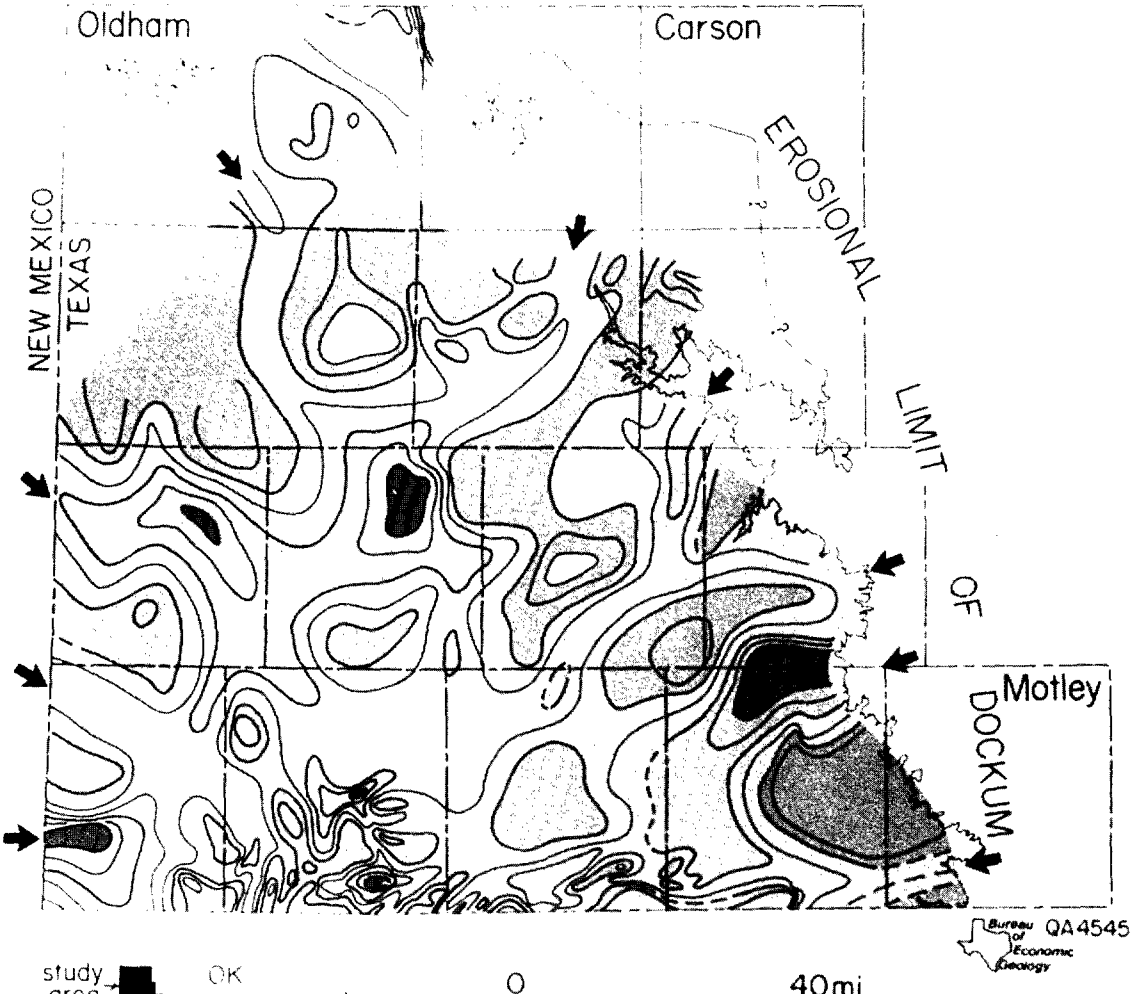
M on Ellenberger
M on basement
IP on basement

QA578

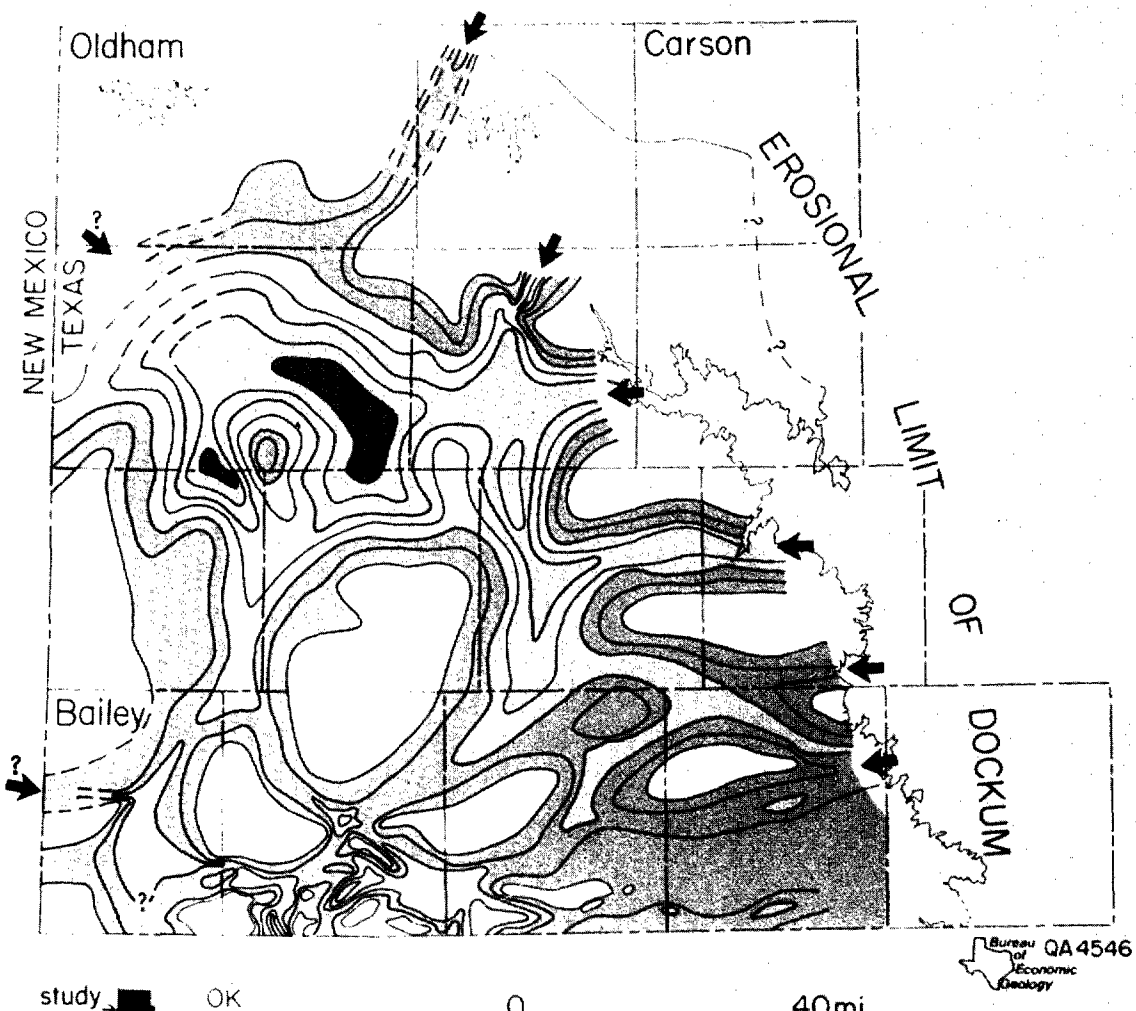

2
N
4500
4000
3500
3000
2500
2000
1500
VE 10x
OLDHAM
DEAF SMITH
CASTRO
LAMB

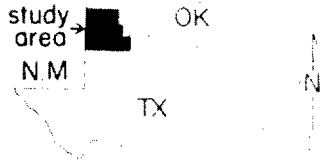

Composite Cross Section
NW
SE
m ft
0 0
25 100
50 200
75 300
100
v.e. = 600X
U Dockum
L
Post Tr
Tr
5
4
3
2
1
Alibates
DS
Ca
Ha
Fl
Sw
QA4557

NET SANDSTONE PACKAGE NO.1



NET SANDSTONE PACKAGE NO.2



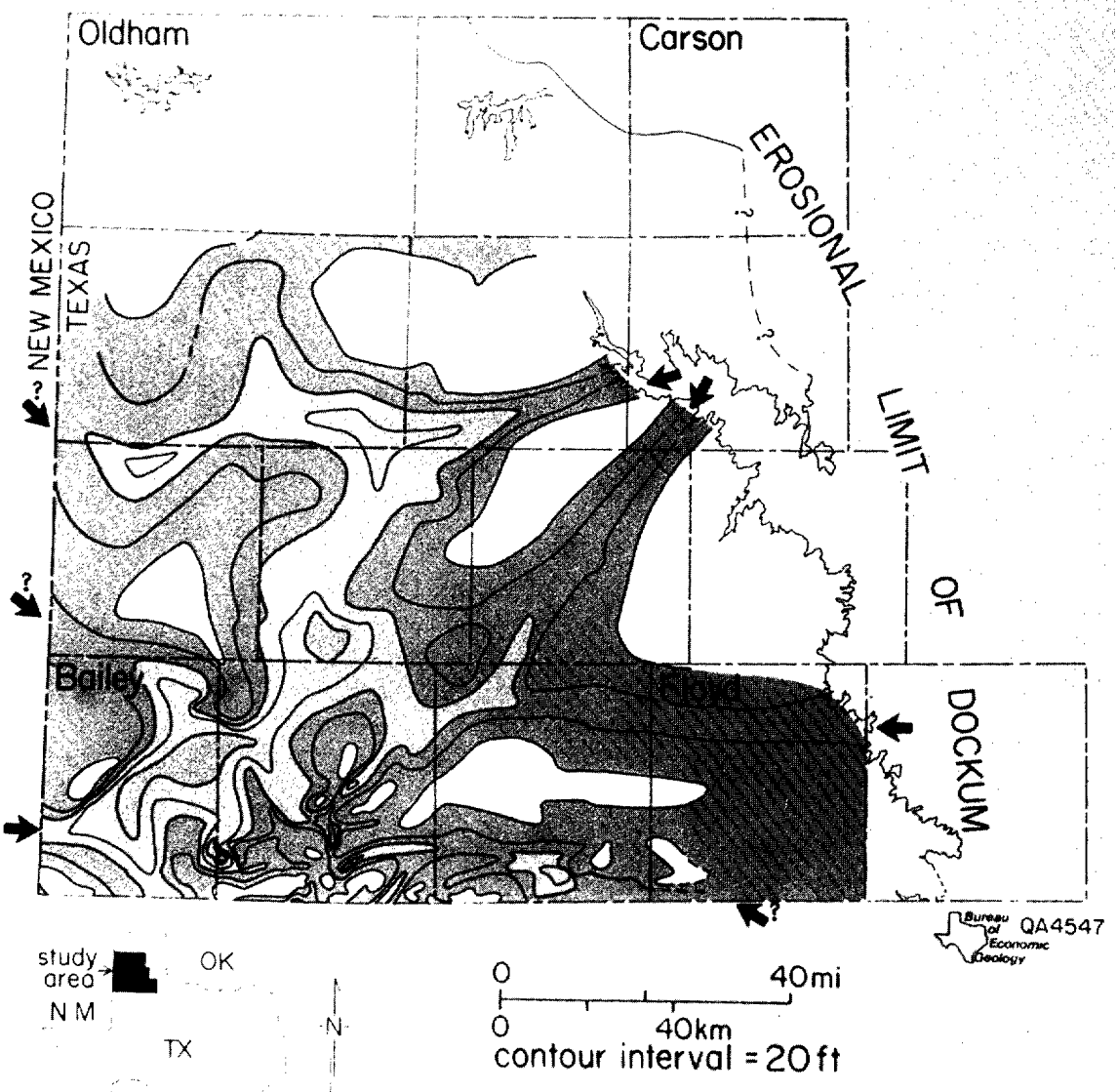


0 40mi
0 40km
contour interval = 20ft

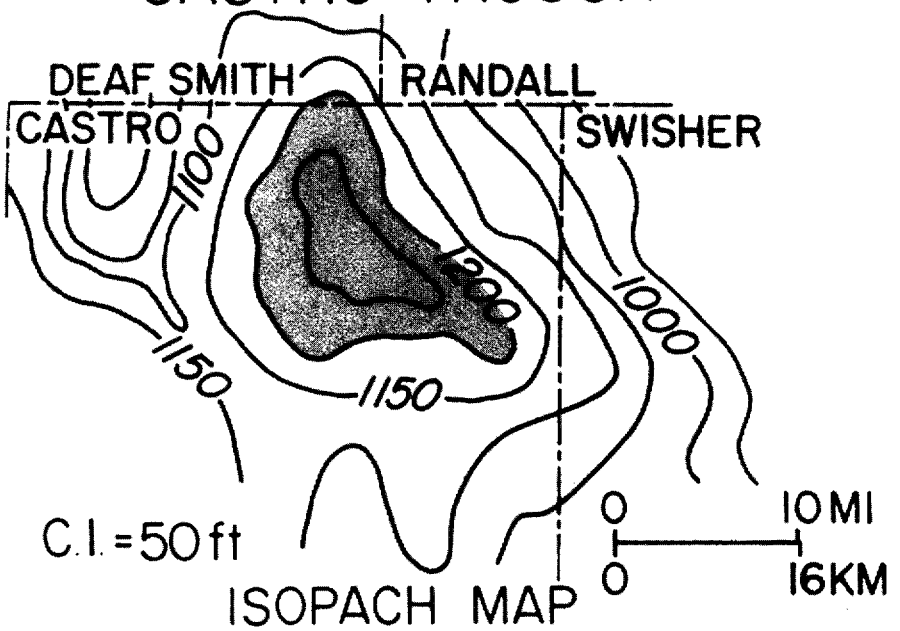
EXPLANATION

0-20	60-100	>140
20-60	100-140	

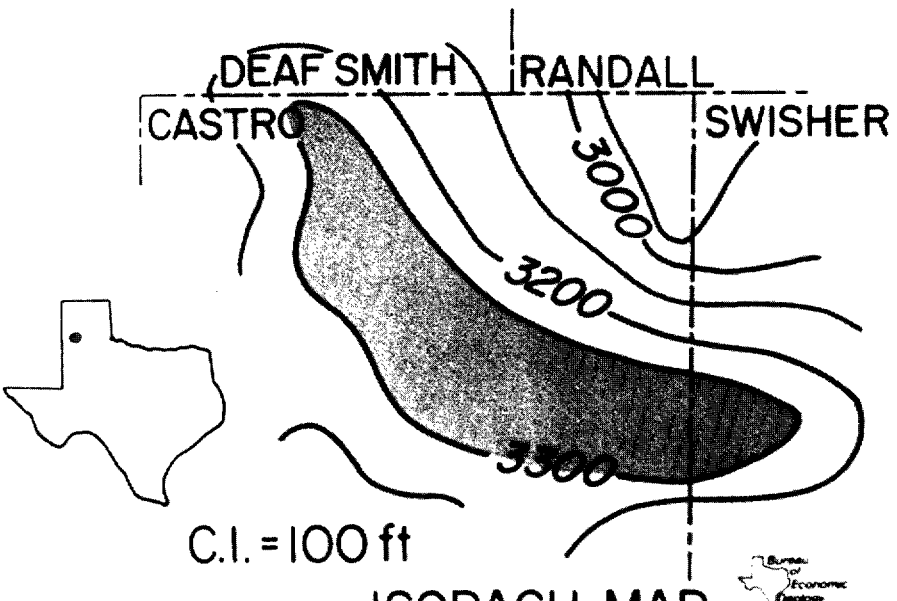
NET SANDSTONE PACKAGE NO.3



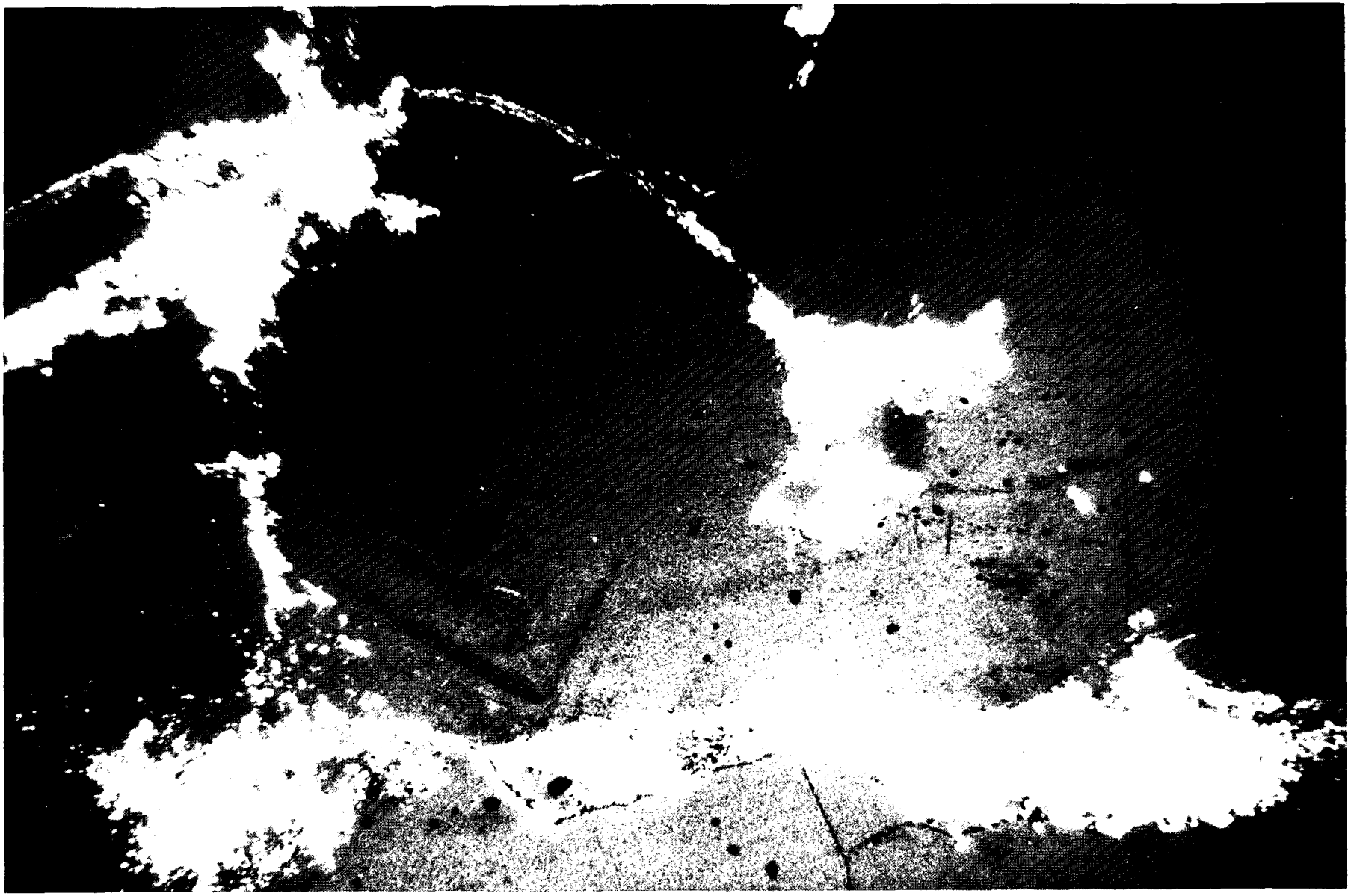
CASTRO TROUGH

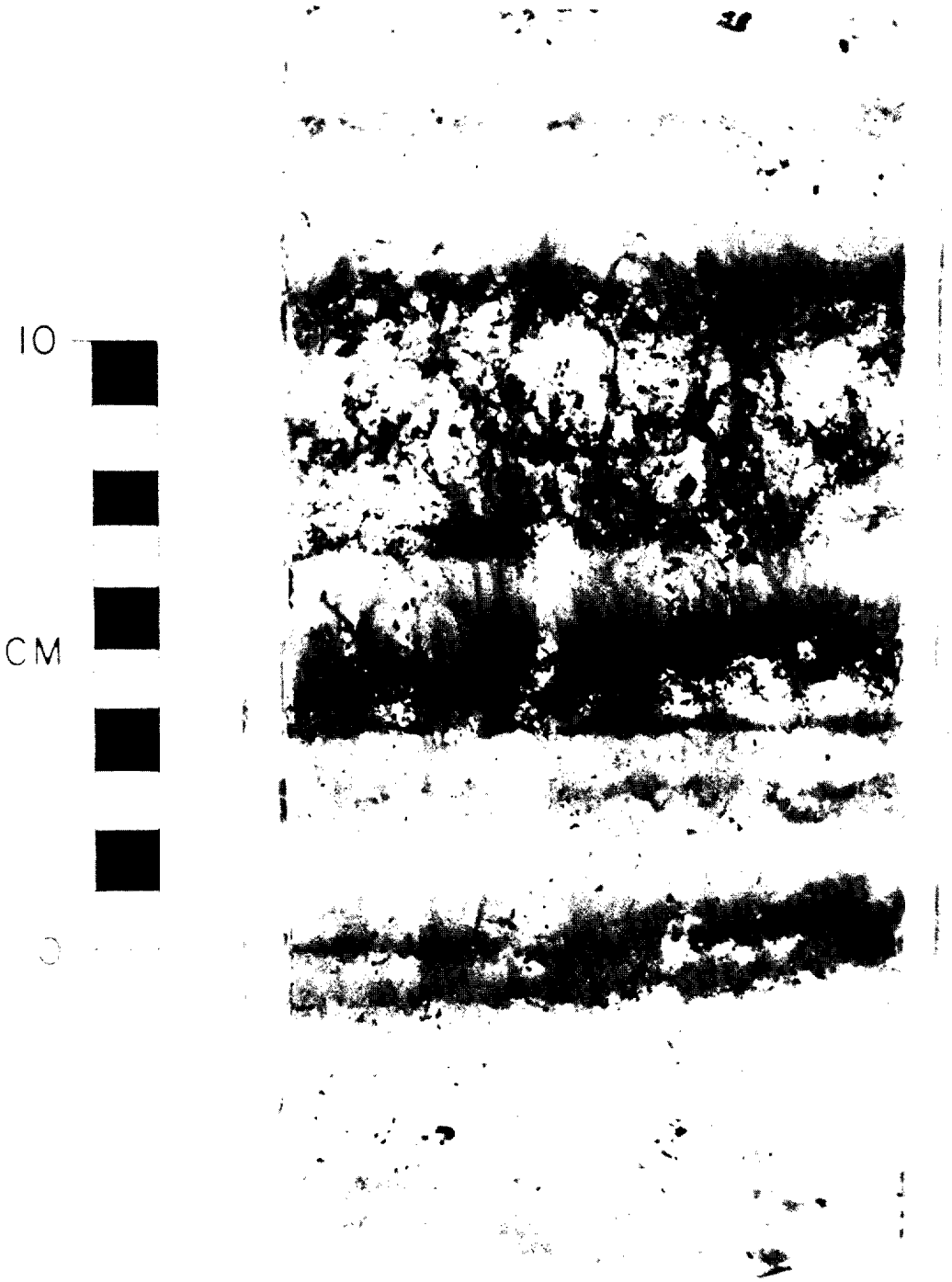


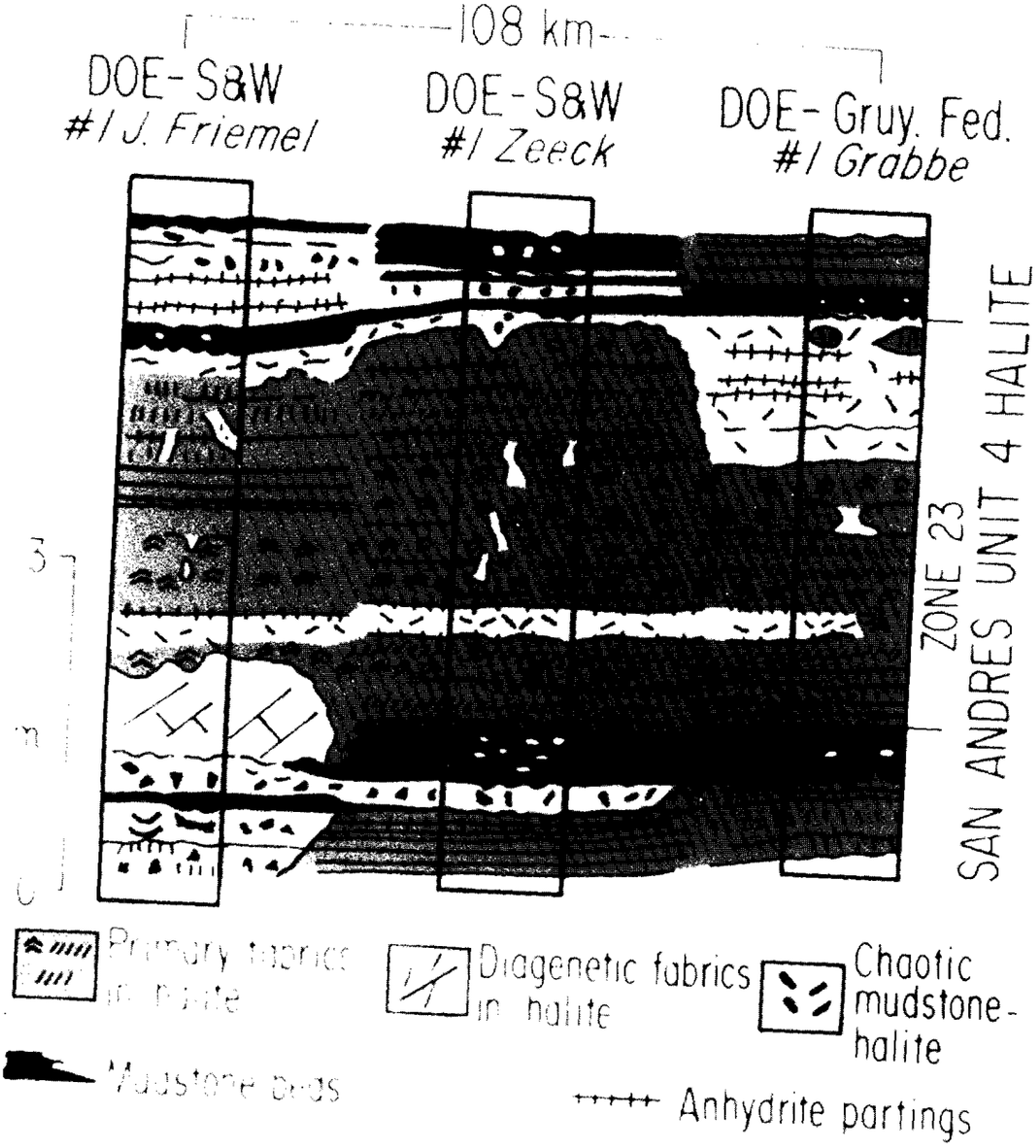
ISOPACH MAP
UPPERMOST PERMIAN - UPPER TRIASSIC
Top of Alibates to base of Ogallala

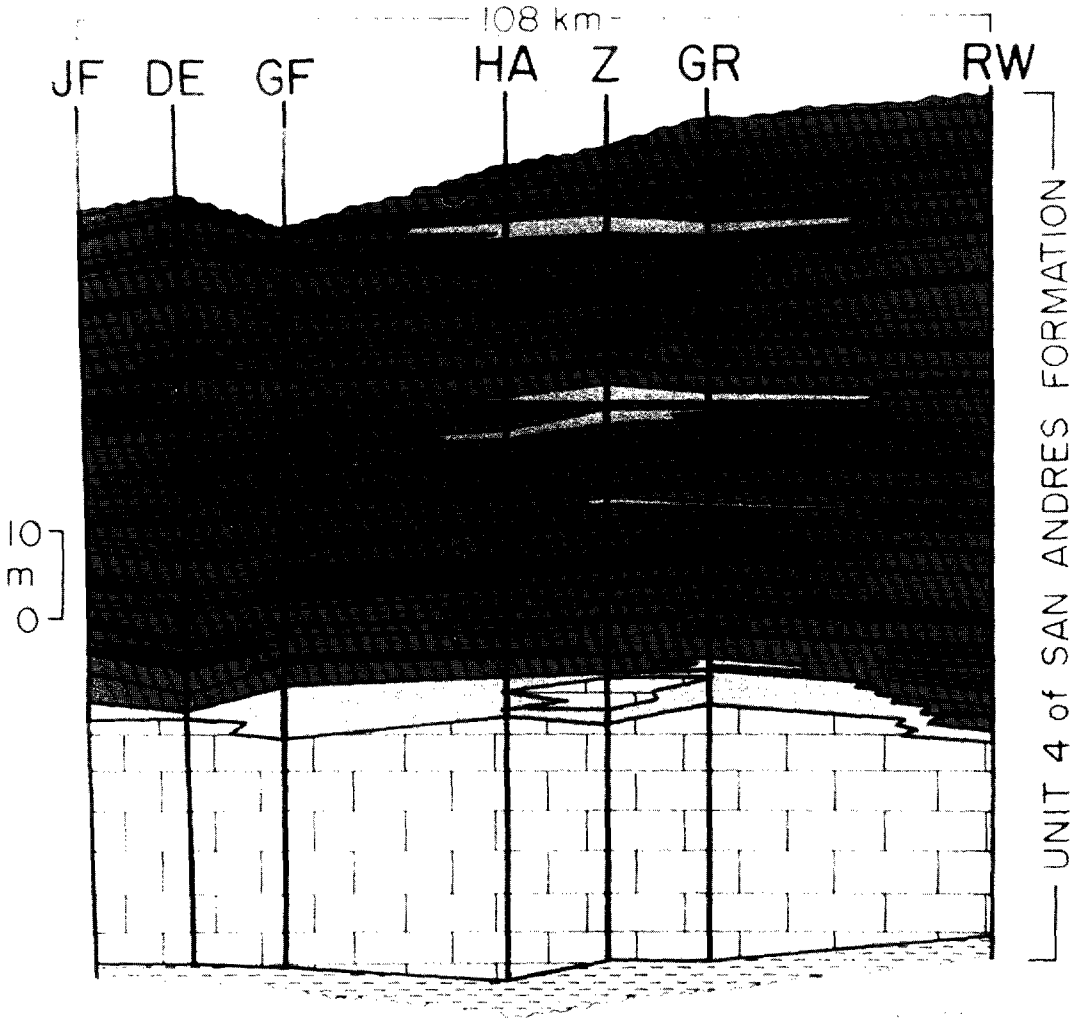


ISOPACH MAP
MIDDLE AND UPPER PERMIAN
Top of Tubb to top of Alibates




10
CM


108 km
DOE-S&W
#1 J. Friemel
DOE-S&W
#1 Zeeck
DOE-Gruy. Fed.
#1 Grabbe
SAN ANDRES UNIT 4 HALITE
ZONE 23
Primary fabrics in halite
Diagenetic fabrics in halite
Chaotic mudstone-halite
Mudstone beds
Anhydrite partings



CORED WELLS:

RW = Rex White, **GR** = Grabbe, **Z** = Zeeck, **HA** = Harman, **GF** = G. Friemel, **DE** = Detten, **J.F** = J. Friemel

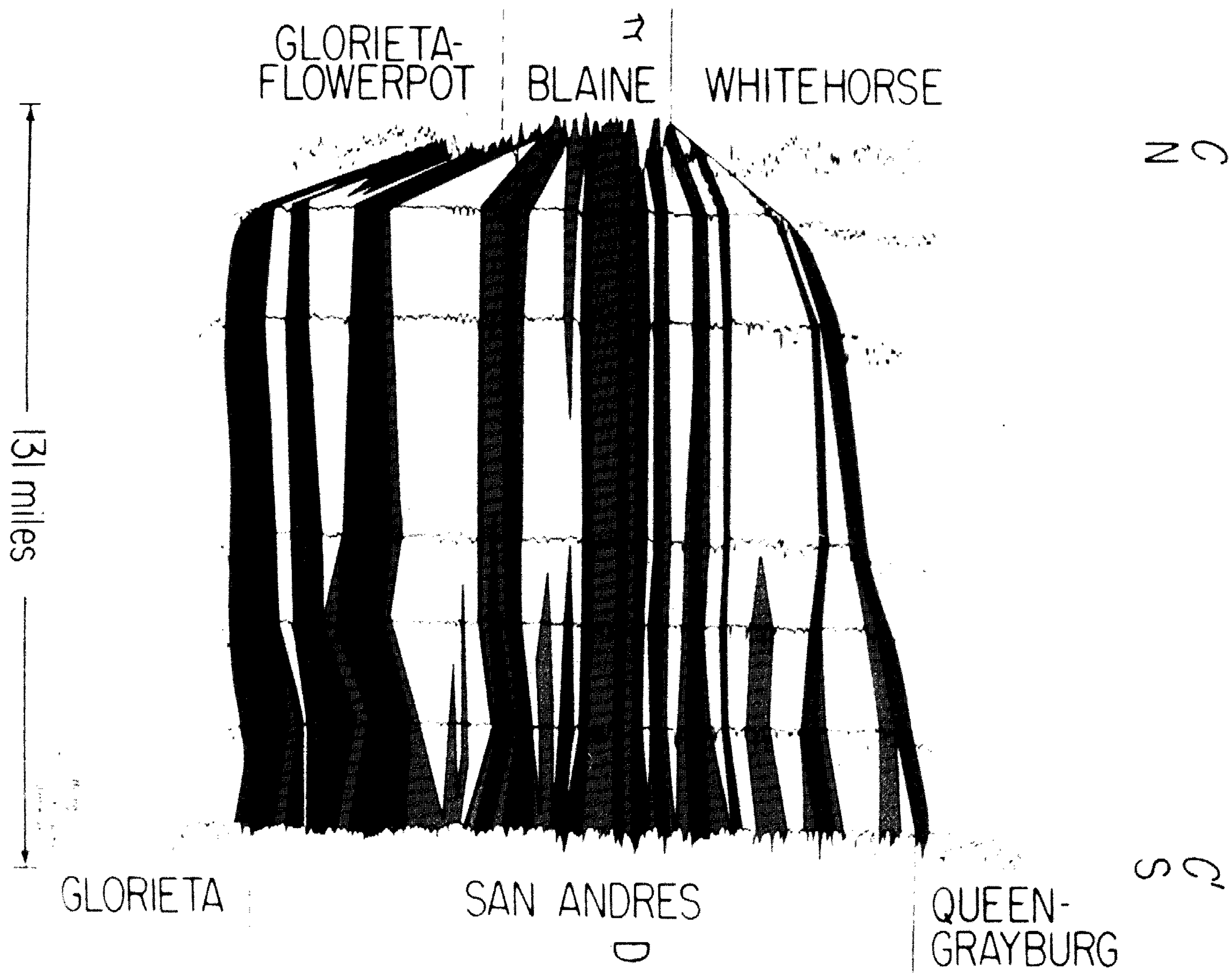
Anhydritic halite

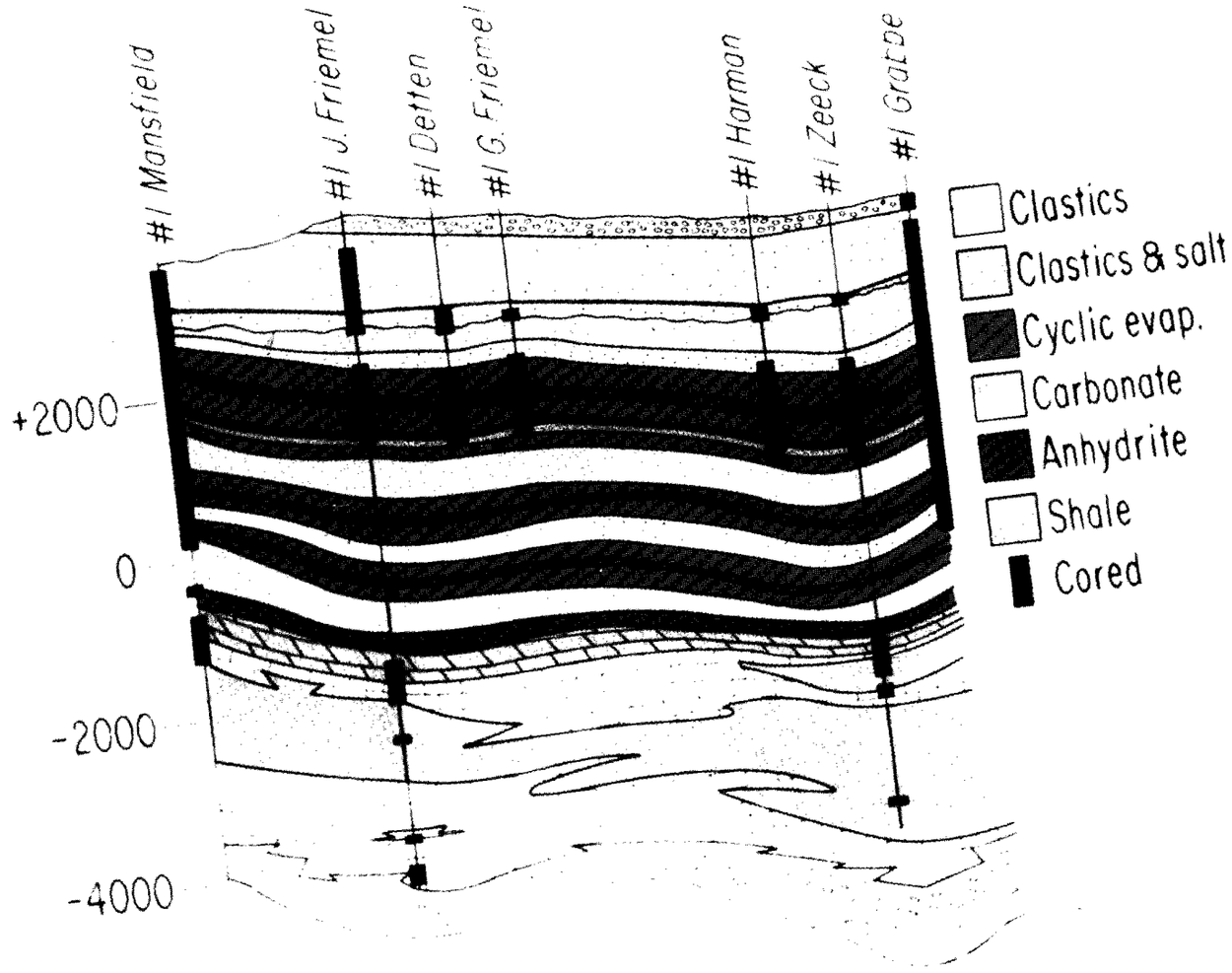
Anhydrite

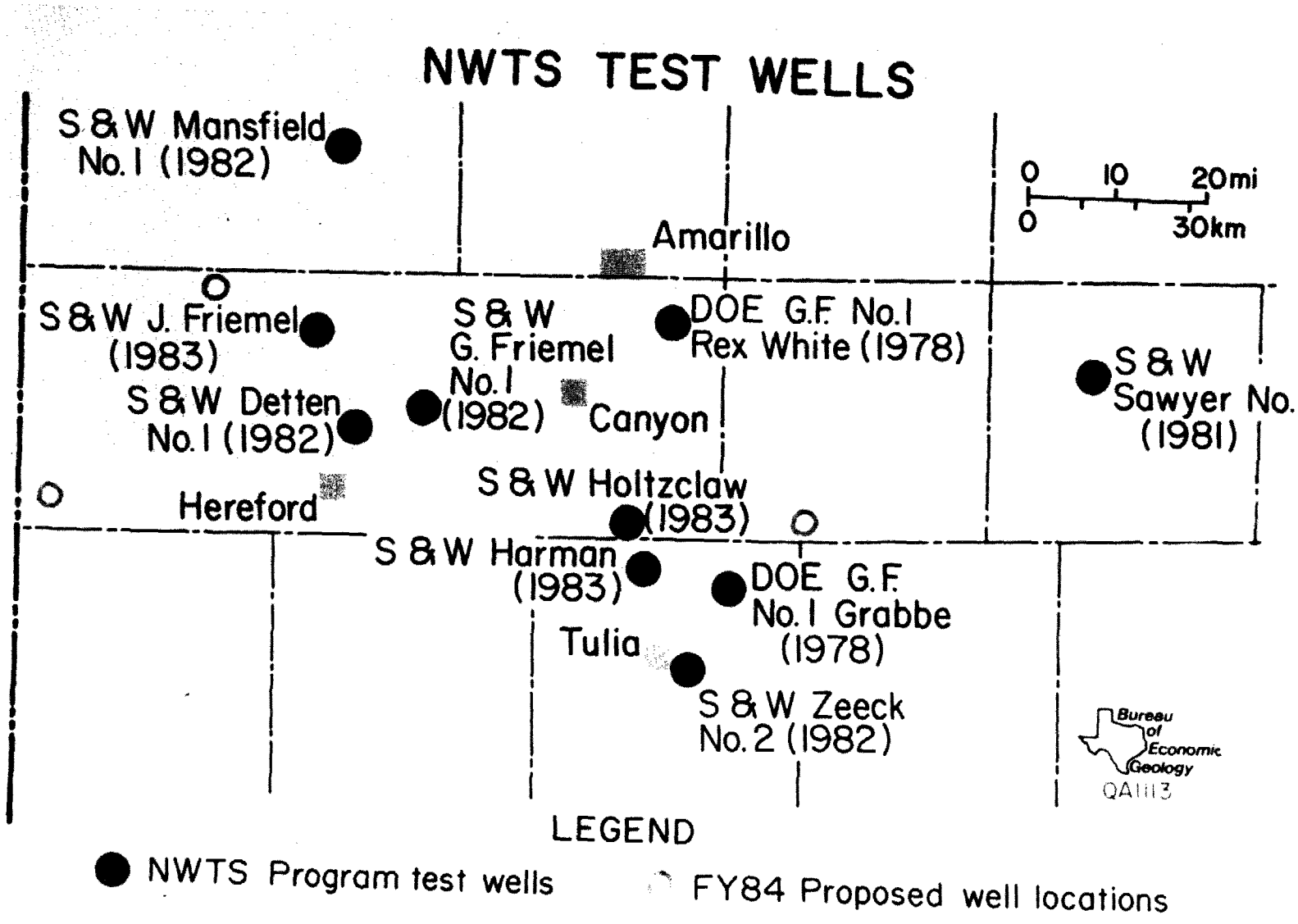
Muddy halite

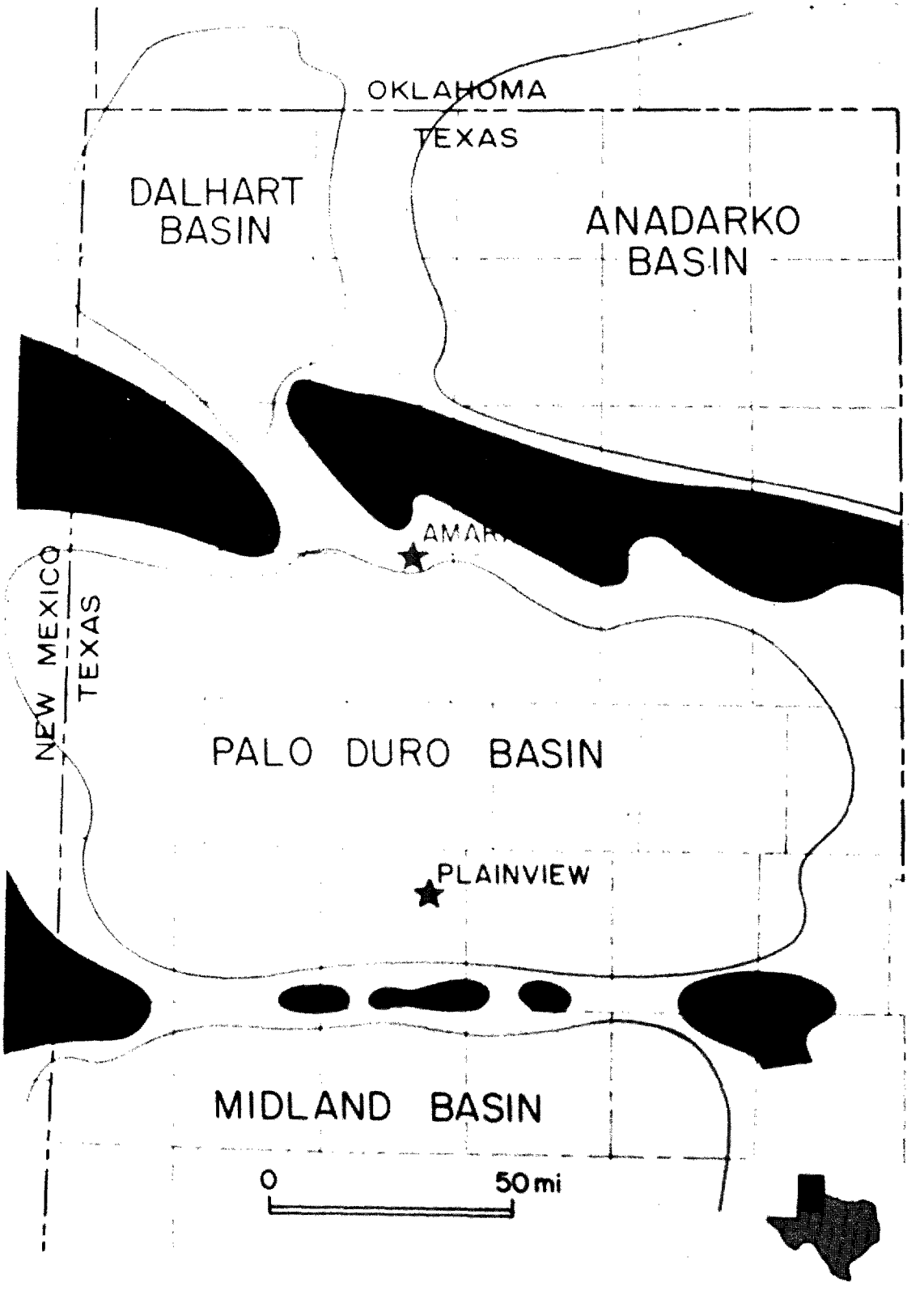
Carbonate

Mud[illegible]


GLORIETA-FLOWERPOT
BLAINE
WHITEHORSE
C
N
131 miles
GLORIETA
SAN ANDRES
D
QUEEN-GRAYBURG
C'
S


#1 Mansfield
#1 J. Friemel
#1 Detten
#1 G. Friemel
#1 Harman
#1 Zeeck
#1 Gratze
+2000
0
-2000
-4000
Clastics
Clastics & salt
Cyclic evap.
Carbonate
Anhydrite
Shale
Cored


NWTS TEST WELLS
S & W Mansfield No. 1 (1982)
Amarillo
0 10 20mi
0 30km
S & W J. Friemel (1983)
S & W G. Friemel No. 1 (1982)
DOE G.F. No. 1 Rex White (1978)
S & W Sawyer No. 1 (1981)
S & W Detten No. 1 (1982)
Canyon
Hereford
S & W Holtzclaw (1983)
S & W Harman (1983)
DOE G.F. No. 1 Grabbe (1978)
Tulia
S & W Zeeck No. 2 (1982)
Bureau of Economic Geology
QA1113
LEGEND
NWTS Program test wells
FY84 Proposed well locations


OKLAHOMA
TEXAS
DALHART
BASIN
ANADARKO
BASIN
AMAR
NEW MEXICO
TEXAS
PALO DURO BASIN
PLAINVIEW
MIDLAND BASIN
0
50 mi

Enclosure 1

Attendance List 11/19/85

NRC/SRP Workshop - Structure & Tectonics of the Palo Duro Basin

Name	Affiliation	Telephone
Jim Hileman	ONWI	(614) 424-7534
AL Fonk	ONWI	(614) 424-4118
Don Turner	ONWI	(614) 424-6186
Ken Johnson	ONWI	(405) 325-3031
Glyn Jones	NRC Woodward Geophysical	(617) 366-9191
Vin Murphy	NRC/Western Geophy.	612 366-8191
A. Ibrahim	NRC	301-427-4211
JB Hoosly	Battelle/ONWI/Rep. Dept.	(614) 424-5536
Owen Swanson	ONWI/Field Ops	FTS 976 5241
Charles KUNTZ	ONWI/GEOTECH. DEPT	614-424-5282
James George	Battelle/ONWI	614-424-5975
Richard Gillespie	Stone & Webster	617-589-2207
Everett Washer	Stone & Webster	617-589-2130
Douglas Pierce	Stone & Webster	617-589-2058
Ed Rossell	ONWI	614 424-6196
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Stanley G Rossier	Stone & Webster	617-589-2053
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NRC/SRP Workshop - Structure & Tectonics of the Palo Duro Basin

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