UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Lithologic descriptions of selected Middle and Upper Jurassic rocks from Gallup to Laguna in northwest New Mexico

by

Steven M. Condon[1]

Open-File Report 85-126

[1]USGS, Denver, Colorado

1985

CONTENTS

ILLUSTRATIONS

LITHOLOGIC DESCRIPTIONS OF SELECTED MIDDLE AND UPPER JURASSIC ROCKS FROM GALLUP TO LAGUNA IN NORTHWEST NEW MEXICO

By Steven M. Condon

INTRODUCTION

The seven sections presented in this report were measured along well-exposed cliffs that mark the transitional boundary between the Zuni Mountains and the San Juan Basin in northwestern New Mexico (fig. 1). The exception to this is the Mesita section (no. 7), which occurs east of the Zunis near the southeastern boundary of the San Juan Basin. The study area is entirely within the Colorado Plateau physiographic province.

The Zuni Mountains are cored by Precambrian granitic and metamorphic rocks and have Pennsylvanian(?), Permian, and Triassic strata exposed on their flanks. The poorly indurated Triassic Chinle Formation in part forms a broad strike valley that separates the vegetated upland of the Zunis from the less vegetated canyon and mesa topography of the southern San Juan Basin. Jurassic and Cretaceous strata are exposed around the edges of the basin, and Tertiary sedimentary rocks are present farther north in the central basin. Tertiary and Quaternary volcanic rocks are exposed in the Mt. Taylor area east of Grants (fig. 1). General geology of the area and references to other literature are provided by Hackman and Olson (1977) and Wyant and Olson (1978).

The purpose of this report is to provide detailed descriptions and thicknesses of some selected Middle and Upper Jurassic rocks in this area. These data can then be used as the basis for surface and subsurface correlations of the Jurassic rocks described.

STRATIGRAPHY

The rocks measured in this study are divided here into two main units, the Middle Jurassic San Rafael Group and the Upper Jurassic Morrison Formation (fig. 2). The San Rafael Group consists of the Entrada Sandstone at the base, the Wanakah Formation, and the Cow Springs Sandstone. The Morrison Formation comprises, from oldest to youngest, the Recapture, Westwater Canyon, and Brushy Basin Members. A unit informally referred to in this report as the sandstone at Mesita (fig. 2) has previously been called the Bluff Sandstone and was included in the San Rafael Group (Rapaport and others, 1952, p. 14; Hilpert, 1963, p. 6), but may belong, in part, with the Morrison Formation. Regional relations of the rocks described are shown as figure 3.

San Rafael Group.--The Entrada Sandstone is the oldest Jurassic formation present in this area and consists of three members, the Iyanbito at the base, the medial silty, and the upper sandy. The Iyanbito and upper sandy members are composed of reddish-orange, very fine to fine-grained, well sorted, flatbedded and cross-stratified sandstone. The medial silty member contains a high percentage of reddish-brown, structureless siltstone, but also contains lenses of fine-grained sandstone. Aggregate thickness of the Entrada is 150-250 ft, of which only the upper few feet were measured in this study.

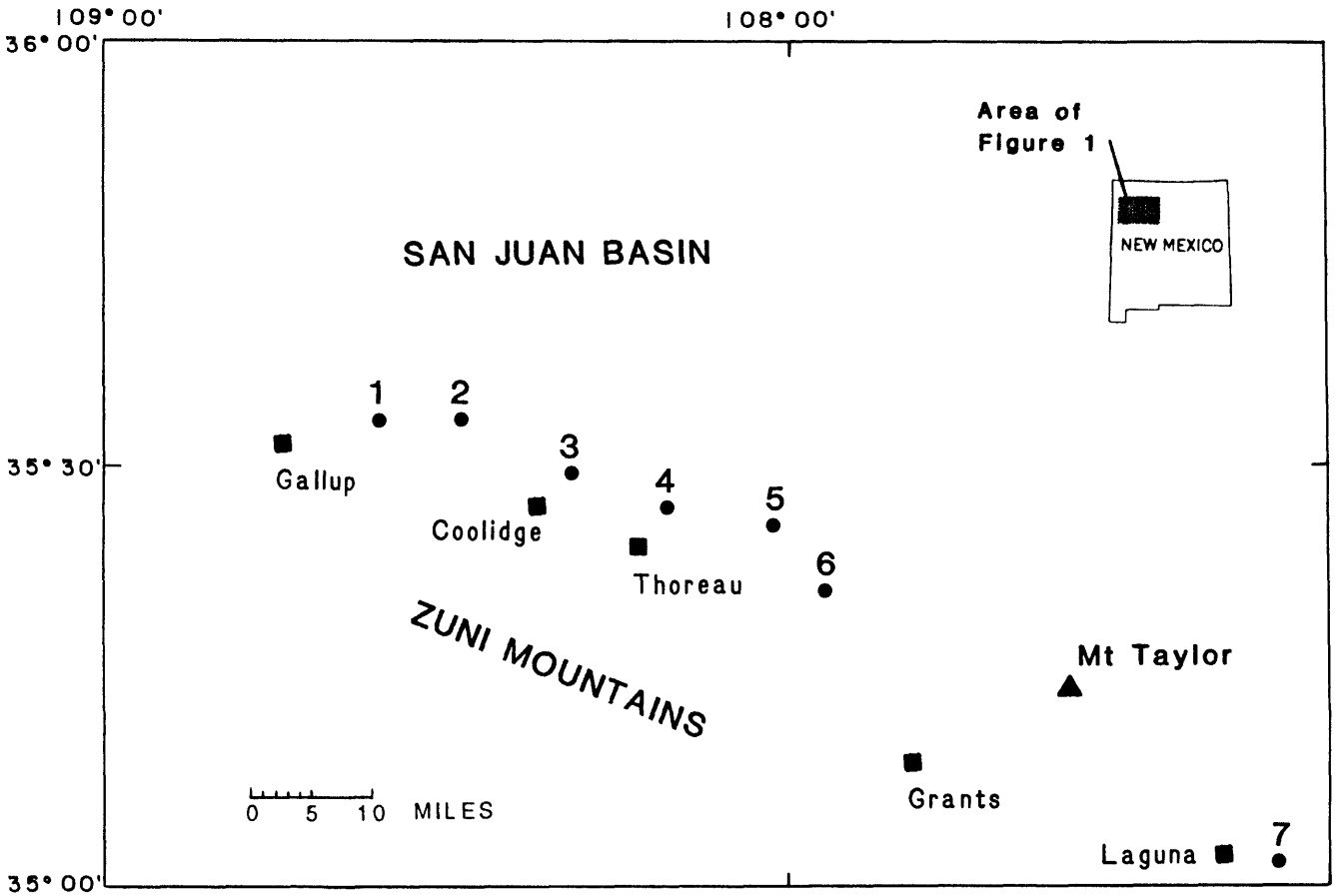


Figure 1. Index map showing locations of measured sections. Numbers refer to the following sections: 1. Navajo Church, 2. Midget Mesa, 3. Pinedale Monocline, 4. East Thoreau, 5. Andrews Ranch, 6. Haystack Mountain, 7. Mesita.

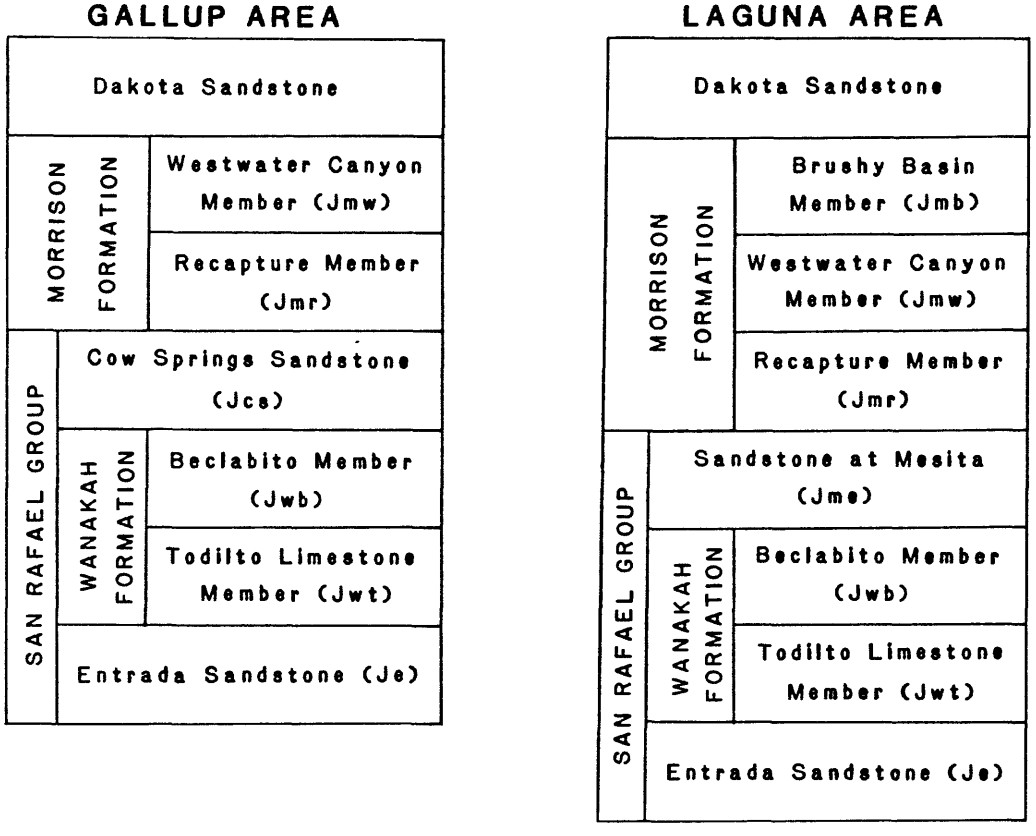


Figure 2. Chart showing nomenclature of this report.

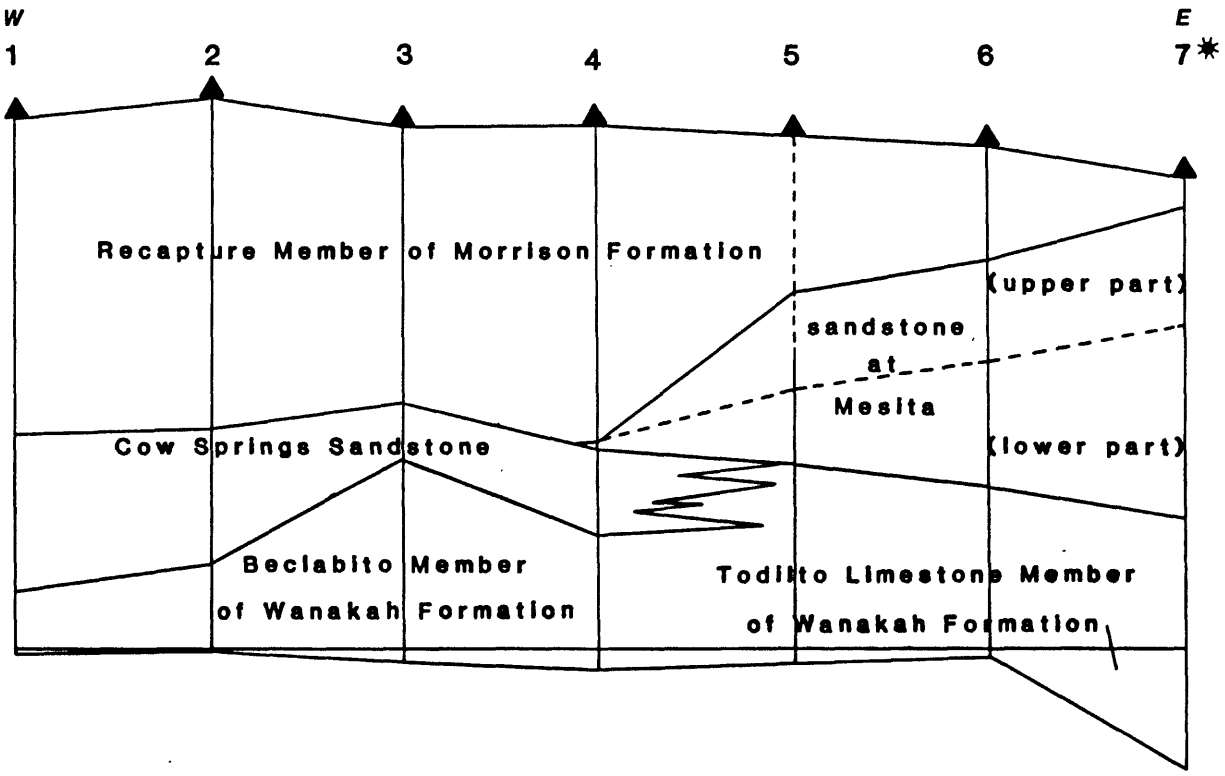


Figure 3. Generalized cross section showing relations between rock units from Gallup to Mesita. Numbers for sections are the same as in figure 1. Vertical scale - 1" = 200'; no horizontal scale. * Thicknesses of Recapture and sandstone at Mesita (formerly Bluff Sandstone) from Craig and others (1959, sec. no. 140).

The Wanakah Formation conformably overlies the Entrada Sandstone and has two members in this area, the Todilto Limestone Member and the Beclabito Member (Condon and Huffman, in press). The Todilto Limestone, which is at the base, consists of light to medium gray, fine- to coarsely crystalline limestone, white gypsum, and minor greenish-gray, calcareous siltstone. The limestone and siltstone display well-developed symmetric and asymmetric ripple marks, and the upper surface of the limestone has dome-shaped undulations and mounds up to 5 feet in diameter in many places. These mounds have been interpreted to be algal structures (Rawson, 1980, p. 307) or to have formed as a result of plastic deformation by loading (Green, 1982). The Todilto thickens from west to east; measured thicknesses range from 3 ft to 125 ft. Green and Jackson (1976) have mapped the pinchout of the limestone a short distance to the west of the westernmost section, Navajo Church (no. 1), and note that the stratigraphic interval is marked by a stringer of granules and pebbles of chert. This stringer appears to correlate with the chert pebbles that occur at the base of the Todilto Limestone at the Navajo Church section. At the eastern end of the outcrop belt (Mesita section, no. 7) the Todilto includes 110 ft of crudely stratified to structureless gypsum.

The Beclabito Member conformably overlies the Todilto Limestone throughout the study area. The Beclabito consists of reddish-orange to reddish-brown, very fine to fine-grained, very well sorted sandstone and reddish-brown siltstone. Sedimentary structures consist of ripple cross-stratification, small-scale trough cross-beds, and flatbedding; many beds have indistinct bedding or are structureless. Siltstone is present in minor amounts in the Gallup area, and in general increases from west to east. In the area between the Midget Mesa section (no. 2) and the East Thoreau section (no. 4) there are numerous white, very fine grained sandstone beds in the upper part of the Beclabito that are lithologically similar to sandstone of the overlying Cow Springs Sandstone. These beds reflect the gradational nature of the contact between the two units. The contact is actually quite arbitrary in many places because the units have similar lithologies and sedimentary structures. Color was used as a general guide for picking the contact, with the Beclabito being shades of red and the Cow Springs being lighter colors of white, green, and pink. The Beclabito also has proportionately more flatbedded units and less crossbedded units than the Cow Springs. Thicknesses of the Beclabito range from 58.5 ft to 196.5 ft; aggregate thicknesses of the Wanakah Formation range from 61.5 to 262.5 ft.

The Cow Springs Sandstone conformably overlies the Wanakah in the Gallup area and grades into the upper part of the Beclabito Member east of Thoreau. The Cow Springs consists of reddish-orange, pinkish-gray, greenish-gray, and white, very fine to fine-grained, well sorted sandstone. Sedimentary structures consist of small- to large-scale trough crossbeds, wavy parallel laminations, and wavy nonparallel laminations (flatbedded units); structureless intervals are present in some places. Laterally extensive horizontal bedding planes that bound depositional units are common in the Cow Springs. Measured thicknesses of the Cow Springs generally decrease from west to east, from 161.5 ft at Navajo Church (no. 1) to 88.5 ft at East Thoreau (no. 4). This is an inverse relationship with respect to the Wanakah Formation, whose thickness generally increases from west to east. The Cow Springs is not recognized east of the Thoreau area.

In the Grants and Laguna areas (sections no. 7, 8, and 9), the sandstone at Mesita occupies a stratigraphic position similar to that of the Cow Springs Sandstone in the Gallup area; however, the lithologies of the two units are different. The contrast is mainly in grain size, sorting, and accessory mineral assemblage. While the Cow Springs is very fine to fine grained and very well sorted, the sandstone at Mesita is fine to medium grained and well to moderately sorted. These are subtle differences, but seem to characterize the two units in most areas. Another feature of the sandstone at Mesita is the presence of coarse grains of white chert that are concentrated on crossbed foresets and in horizontal layers; these grains were not noted in any of the sections measured of Cow Springs Sandstone. Sedimentary structures of the two units are similar, consisting of small- to large-scale trough crossbedding, wavy parallel laminations, and wavy nonparallel laminations (flatbedding). Both units show an increase in large-scale crossbedding upwards in the section; a thickness of about 40 feet for one crossbed set in the sandstone at Mesita was recorded by Craig and others (1959, sec. no. 140). Complete thicknesses of the sandstone at Mesita were measured at only two places (East Thoreau, no. 4, and Haystack Mountain, no. 6, and range from 5.5 ft to 126.5 ft. Craig and others (1959, sec. no. 140) measured 317 ft of the unit just east of the Mesita section.

The sandstone at Mesita has previously been called the Bluff Sandstone (Rapaport and others, 1952; Freeman and Hilpert, 1956; Craig and others, 1959) in the Grants and Laguna areas. Maxwell (1976, 1982) has applied the name Bluff Sandstone to the lower part of the unit and the name Zuni Sandstone to the upper part in the area south and west of Laguna. Maxwell divides the unit into two parts on the basis of differences in sedimentary structures and inferred environments of deposition.

I believe that Maxwell's division of the unit is valid, but that the lower part has affinities with the underlying San Rafael Group and the upper part should possibly be included in the Morrison Formation. The reasons for this interpretation are thus: (1) The contact between the sandstone at Mesita and the underlying Beclabito Member of the Wanakah Formation, while sharp and erosional at one section (Andrews Ranch, no. 5), is more commonly conformable. Deposition of the lower part of the sandstone at Mesita seems to be a continuation of the same processes that deposited the underlying Beclabito Member of the Wanakah. In the one section where the sandstone at Mesita overlies the Cow Springs Sandstone (East Thoreau, no. 4) the contact also appears conformable. (2) The contact between the upper part of the sandstone at Mesita and the Recapture Member of the Morrison Formation is conformable, and the two units interfinger in the Laguna area (Freeman and Hilpert, 1956, p. 313). This implies that deposition of the two units occurred at least in part simultaneously. Further work needs to be done on the sandstone at Mesita, particularly concerning the contact between the upper and lower parts of the unit.

Morrison Formation.--The Recapture Member is the basal member of the Morrison Formation in the southern San Juan Basin. Pipiringos and O'Sullivan (1978, p. A25) stated that there is an unconformity at the base of the Morrison Formation or equivalent units throughout most of the Western Interior, and have shown one in the vicinity of Navajo Church (Pipiringos and O'Sullivan, 1978, pl. 1, section C-C'). In the area of this study, the contact between the Recapture and the Cow Springs Sandstone appears to be

planar; no channeling was noted. In many places the contact appeared to be gradational and was difficult to pick with certainty. As noted previously, Freeman and Hilpert (1956, p. 313) described interfingering between the Recapture and the sandstone at Mesita (formerly Bluff Sandstone).

In many areas the Recapture can be divided into two parts, lower and upper. The lower part consists of white, yellowish-gray, and purplish-gray, fine- to medium-grained, moderately well to well-sorted sandstone, and minor interbedded reddish-brown siltstone and mudstone. Sedimentary structures are medium- to very large scale, high angle trough and tabular-planar crossbeds and flatbeds; structureless intervals are common. This unit varies in thickness from about 100 ft to about 240 ft and weathers to vertical cliffs in many places. The upper part, which is lithologically more heterogeneous, consists of white to light brown, fine- to coarse-grained, well to poorly sorted sandstone, and reddish-brown mudstone and siltstone. The sandstone beds commonly are lenticular, have irregular scoured bases, and fine upwards. Sedimentary structures consist of small- to medium-scale trough crossbeds and ripple cross-stratification. The mudstones and siltstones are commonly structureless, but ripple cross-stratification is present; horizontal bands of calcareous concretions are present in some fine-grained interbeds, usually just below an overlying sandstone. The thickness of this unit varies from about 85 ft to about 200 ft. The combined thickness of the lower and upper parts of the Recapture ranges from about 225 ft to about 340 ft.

The Westwater Canyon Member conformably overlies the Recapture Member. The Westwater Canyon consists of reddish-orange to grayish-purple, fine- to coarse-grained, moderately well to poorly sorted sandstone and minor interbedded reddish-brown mudstone. Sedimentary structures vary from trough and tabular-planar crossbeds to horizontal laminations. In some areas lenses of pebbles are present. These commonly occur at the base of crossbed sets. Only the lowest few feet of Westwater Canyon were measured in this study.

The upper member of the Morrison in this area, the Brushy Basin, was not measured or described as part of this study.

METHODS

Nearly all of each section was measured with a 5 ft Jacob's staff and Abney level. A cloth or metal tape was used when cliffs precluded use of the Jacob's staff. Structural dip in this area is low, ranging from 1° to 4°, and vegetation posed no problem. Lithologic data were recorded on the section-measuring forms that are reproduced in Appendix II. Each section has a header card that shows what kind of information each column contains. The other cards for each section are continuation sheets that do not have the columns labeled. The forms are designed to be attached together to form a continuous strip chart of lithologic data. (See Appendix I for a complete explanation of the forms.) Finally, thanks go to Bob Pool for able assistance in the field.

REFERENCES CITED

Condon, S. M., and Huffman, A. C., Jr., in press, Revisions in nomenclature of the Middle Jurassic Wanakah Formation, northwest New Mexico and northeast Arizona: U.S. Geological Survey Bulletin 1633-A.

Craig, L. C., Holmes, C. N., Cadigan, R. A., Freeman, V. L., Mullens, T. E., and Weir, G. W., 1959, Measured sections of the Morrison and adjacent formations: U.S. Geological Survey Open-File Report, 700 p.

Freeman, V. L., and Hilpert, L. S., 1956, Stratigraphy of the Morrison Formation in part of northwestern New Mexico: U.S. Geological Survey Bulletin 1030-J, p. 309-334.

Goddard, E. N., Trask, P. D., De Ford, R. K., Rove, O. N., Singewald, J. T., Jr., and Overbeck, R. M., 1948, Rock-color chart: The Geological Society of America.

Green, M. W., 1982, Origin of intraformational folds in the Jurassic Todilto Limestone, Ambrosia Lake uranium mining district, McKinley and Valencia Counties, New Mexico: U.S. Geological Survey Open-File Report 82-69, 26 p.

Green, M. W., and Jackson, T. J., 1976, Geologic and structure contour maps of the Gallup East quadrangle, McKinley County, New Mexico: U.S. Geological Survey Open-File Report 76-453, scale 1:24,000.

Hackman, R. J., and Olson, A. B., 1977, Geology, structure, and uranium deposits of the Gallup 1° x 2° quadrangle, New Mexico: U.S. Geological Survey Miscellaneous Investigations Series Map I-981, scale 1:250,000.

Hilpert, L. S., 1963, Regional and local stratigraphy of uranium-bearing rocks, in Kelley, V. C., compiler, Geology and technology of the Grants uranium region: New Mexico Bureau of Mines and Mineral Resources Memoir 15, p. 6-18.

Maxwell, C. H., 1976, Stratigraphy and structure of the Acoma region, New Mexico, in Woodward, L. A., and Northrop, S. A., eds., Tectonics and mineral resources of southwestern North America: New Mexico Geological Society Special Publication No. 6, p. 95-101.

_____1982, Mesozoic stratigraphy of the Laguna-Grants region, in Grambling, J. A., and Wells, S. G., eds., Albuquerque Country II, 33rd Field Conference: New Mexico Geological Society, p. 261-266.

Pipiringos, G. N., and O'Sullivan, R. B., 1978, Principal unconformities in Triassic and Jurassic rocks, Western Interior United States-A preliminary survey: U.S. Geological Survey Professional Paper 1035-A, 29 p.

Rapaport, Irving, Hadfield, J. P., and Olsen, R. H., 1952, Jurassic rocks of the Zuni uplift, New Mexico: U.S. Atomic Energy Commission, RMO-642, 49 p.

Rawson, R. R., 1980, Uranium in Todilto Limestone (Jurassic) of New Mexico-example of a sabkha-like deposit, in Rautman, C. A., compiler, Geology and mineral technology of the Grants uranium region, 1979: New Mexico Bureau of Mines and Mineral Resources Memoir 38, p. 304-312.

Wyant, D. J., and Olson, A. B., 1978, Preliminary geologic map of the Albuquerque 1° x 2° quadrangle, northwestern New Mexico: U.S. Geological Survey Open-File Report 78-467, scale 1:250,000.

APPENDIX I

Explanation of section forms

The section forms in this report are divided into vertical columns that contain different types of information. Each column will be discussed briefly below.

Thickness/sample no. In this report this column is used to indicate thicknesses of the units in feet.

Unit no. This column could be used to number each depositional unit. The units are not numbered in this report.

Fm/mbr. Formation and member names are shown in this column. Abbreviations for formations and members are shown on figure 2.

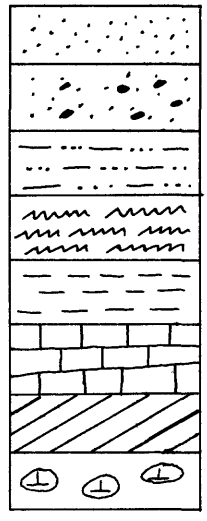
Radioact./CPS. CPS refers to counts-per-second of a hand-held scintillometer. This column was not used in this report.

Visual porosity estimate. This column is a continuous line graph representing an estimate of the porosity of the unit measured. Estimates were obtained by placing a few drops of water or dilute HCl on the rock.

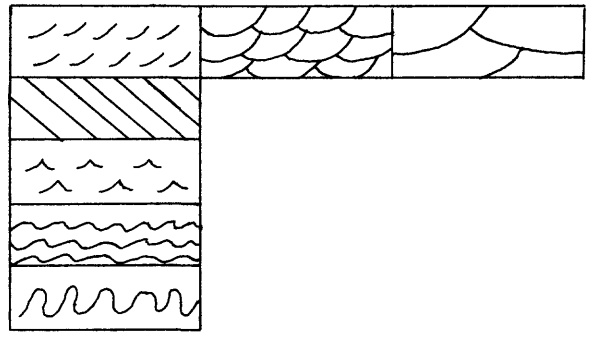
Core. This indicates the number of the core run for subsurface studies. It was not used in the present report.

Rock type. The rock type column contains a weathering profile of the outcrop, a lithologic symbol for rock type, sketches of sedimentary structures within the units, and circled numbers that designate the position of samples taken. Small strike and dip symbols next to some intervals indicate the presence of calcareous zones.

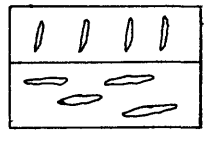
Lithology	Symbol
Sandstone	
Conglomeratic sandstone	
Siltstone	
Mudstone	
Claystone	
Limestone	
Gypsum	
Limestone clasts or nodules	



Sedimentary structures	Symbol		
	small	medium	large
Trough or wedge-planar crossbeds			
Tabular-planar crossbeds			
Ripples (current or oscillation)			
Adhesion ripples (flatbedding)			
Contorted bedding			



Miscellaneous	Symbol
Burrows	
Vertical	
Horizontal	



Footnotes/Color. Both these columns are used to indicate color of the units. Colors were estimated by a comparison with the GSA Rock-color chart (Goddard and others, 1948). Where possible, colors were estimated from fresh, dry outcrops.

Dominant grain size. The dominant grain size of rock units was estimated by comparing them to standard grain size charts. Class divisions correspond to the phi scale. Dots to the left or right of the solid line indicate variations from the norm.

Bedding. Bedding refers to set thickness of sedimentary units. Abbreviations are as follows: VTK - very thick; TK - thick; M, MED, or AV - medium; TN - thin; VTN - very thin; LAM - laminated; MASS - massive. Combinations of terms indicates a range of bedding thicknesses.

Sedimentary structures. This column indicates the type of sedimentary structure that is shown graphically in the rock type column. Abbreviations of sedimentary structures are as follows: CLL - curved, parallel laminations, (trough or wedge-planar crossbeds); in some cases the scale of the crossbeds is indicated; TAB. PLANAR - tabular-planar crossbeds; DWLL - discontinuous, wavy, nonparallel laminations, (current or oscillation ripples); WLL - wavy, nonparallel laminations, (adhesion ripples); ELL - even, parallel laminations, (horizontal laminations); STRLESS - structureless.

Biology/organics. This column indicates the presence of organic material, burrowing, and bioturbation.

Sorting/roundness. Commonly used abbreviations for sorting are as follows: VWS - very well sorted; WS - well sorted; MWS - moderately well sorted; M or MOD - moderately sorted; FS - fair sorting; PS - poorly sorted. Abbreviations for roundness include: A - angular; SA - subangular; SR - subrounded; R - rounded. Many abbreviations are combinations of the above letters.

Cement. This column was used to indicate the presence of calcite cement. Abbreviations used include: VC - very calcareous; MC - moderately calcareous; SC - slightly calcareous; NC - non-calcareous.

Percent feldspar. Estimated percent feldspar, usually potassium feldspar, in the unit.

Accessory minerals or fragments. Colors of unidentified accessory minerals are in this column. Abbreviations for colors are: BLK - black; R or RD - red; OR - orange; GRN - green; GY - gray; WT - white.

Notes. This is essentially a "comments" section. It contains miscellaneous information not covered on the rest of the form.

Inferred environment of deposition. Possible environments of deposition are noted in this section. These interpretations are preliminary, and two or more possibilities are often listed.

Transport direction. Where possible, estimates of the direction of sediment transport were made. Most of these estimates were taken from axes of trough crossbeds.

APPENDIX II

Measured sections

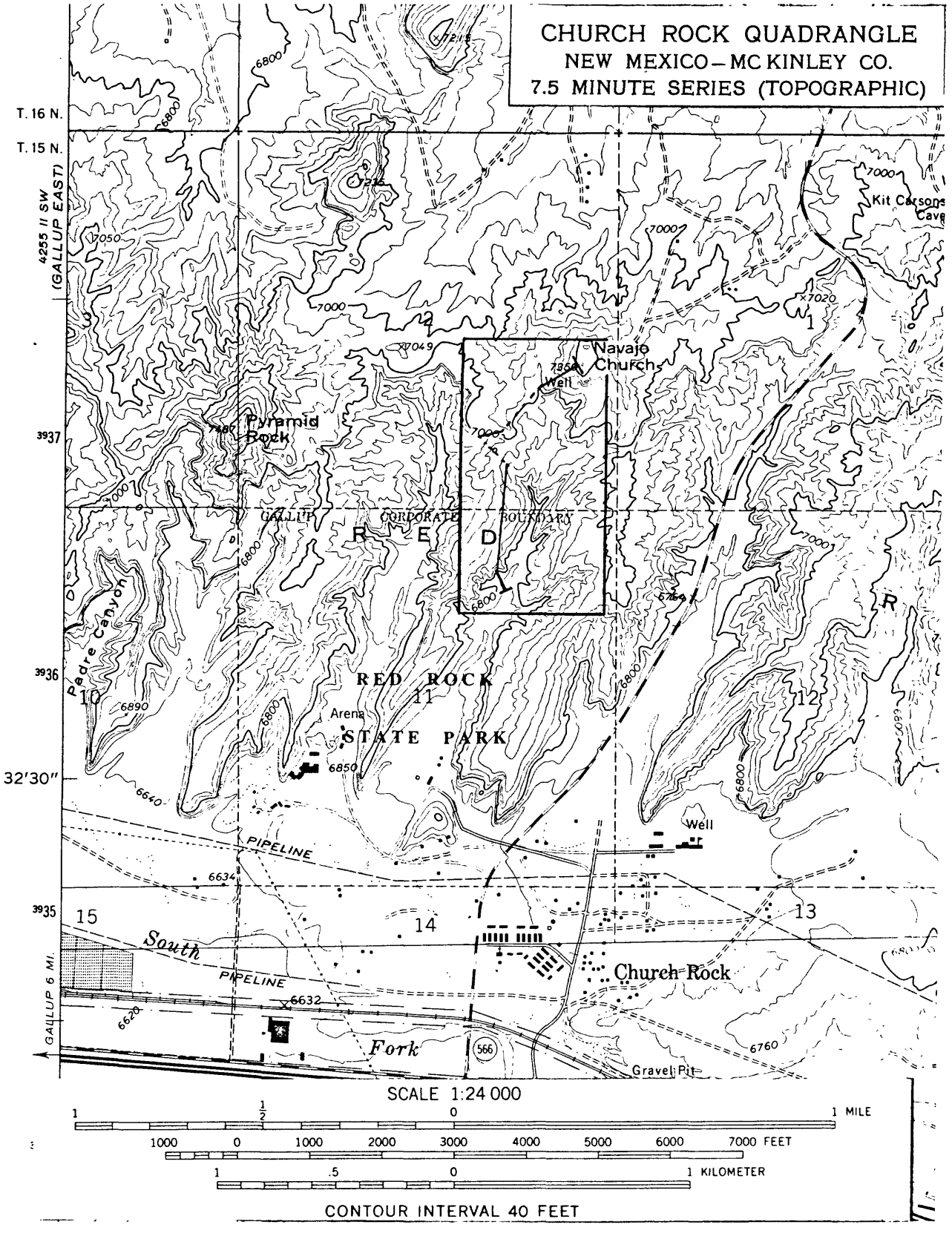
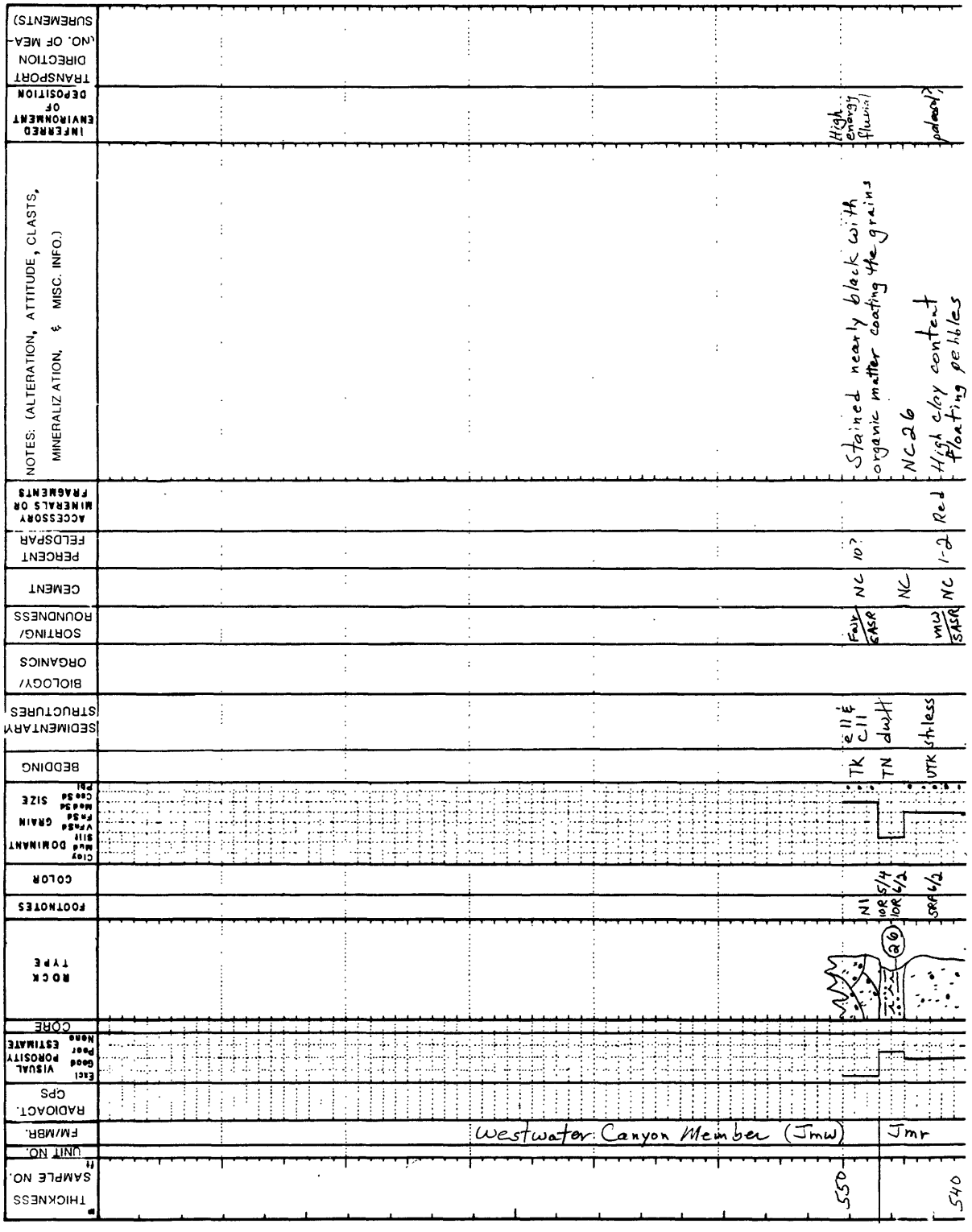


Figure 4. Location of Navajo Church section.

STRATIGRAPHIC SECTION DESCRIPTION (STRAT. INTERVAL Je ..... TO Jmw)

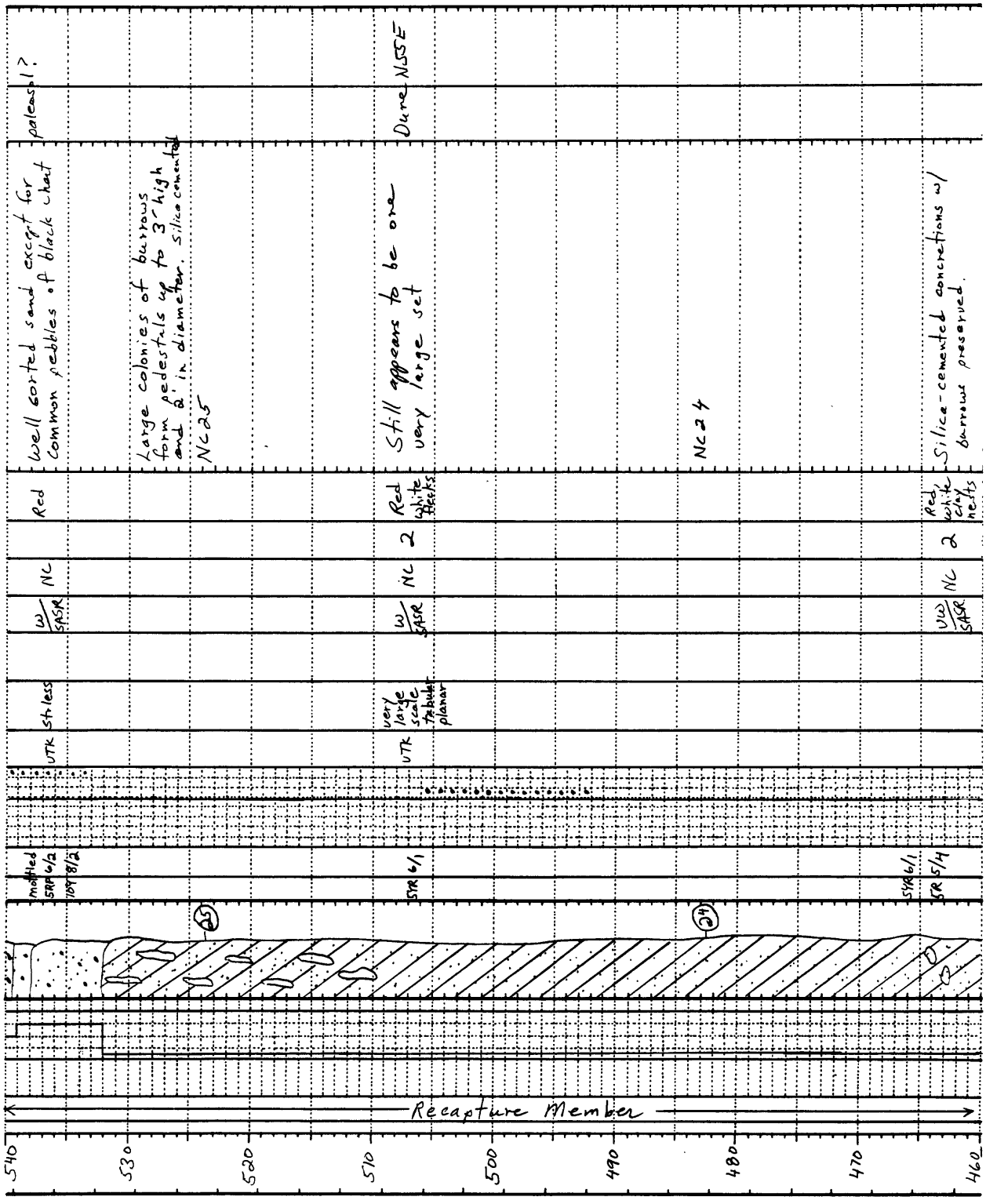
1. LOCATION Navajo Church Sec 2/11 T. 16N R. 17W QUADRANGLE (7.5') Church Rock
STATE New Mexico COUNTY McKinley DATE 7/9-7/11 1964
LAT.-LONG. GEOL. Condon, Pool



LOCATION Navajo Church Sec. 2, 11 T. 15 N. R. 17 W.

STATE ..... COUNTY .....

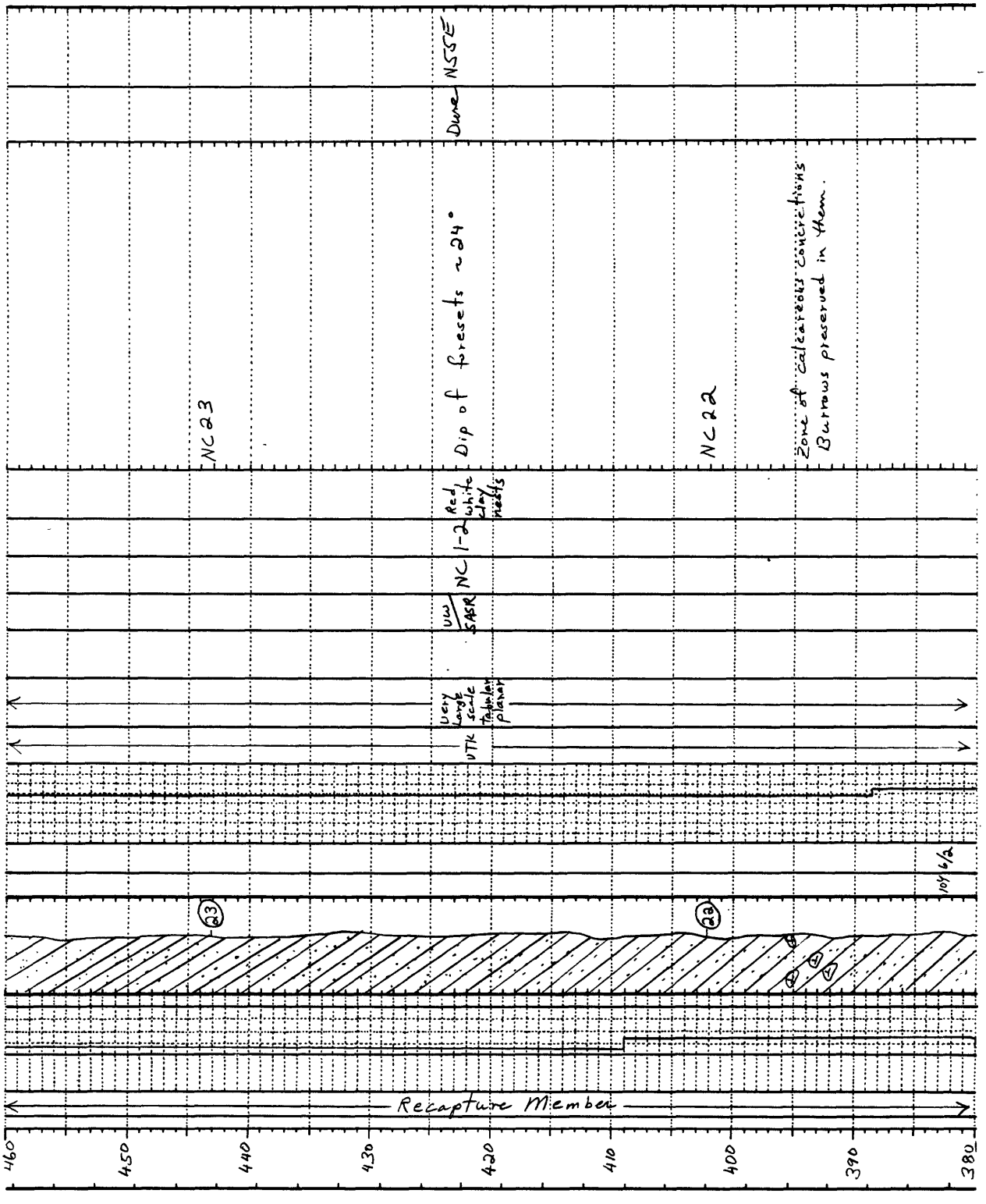
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Navajo Church Sec. 2, 11 T. 15N. R. 17W.

STATE ..... COUNTY .....

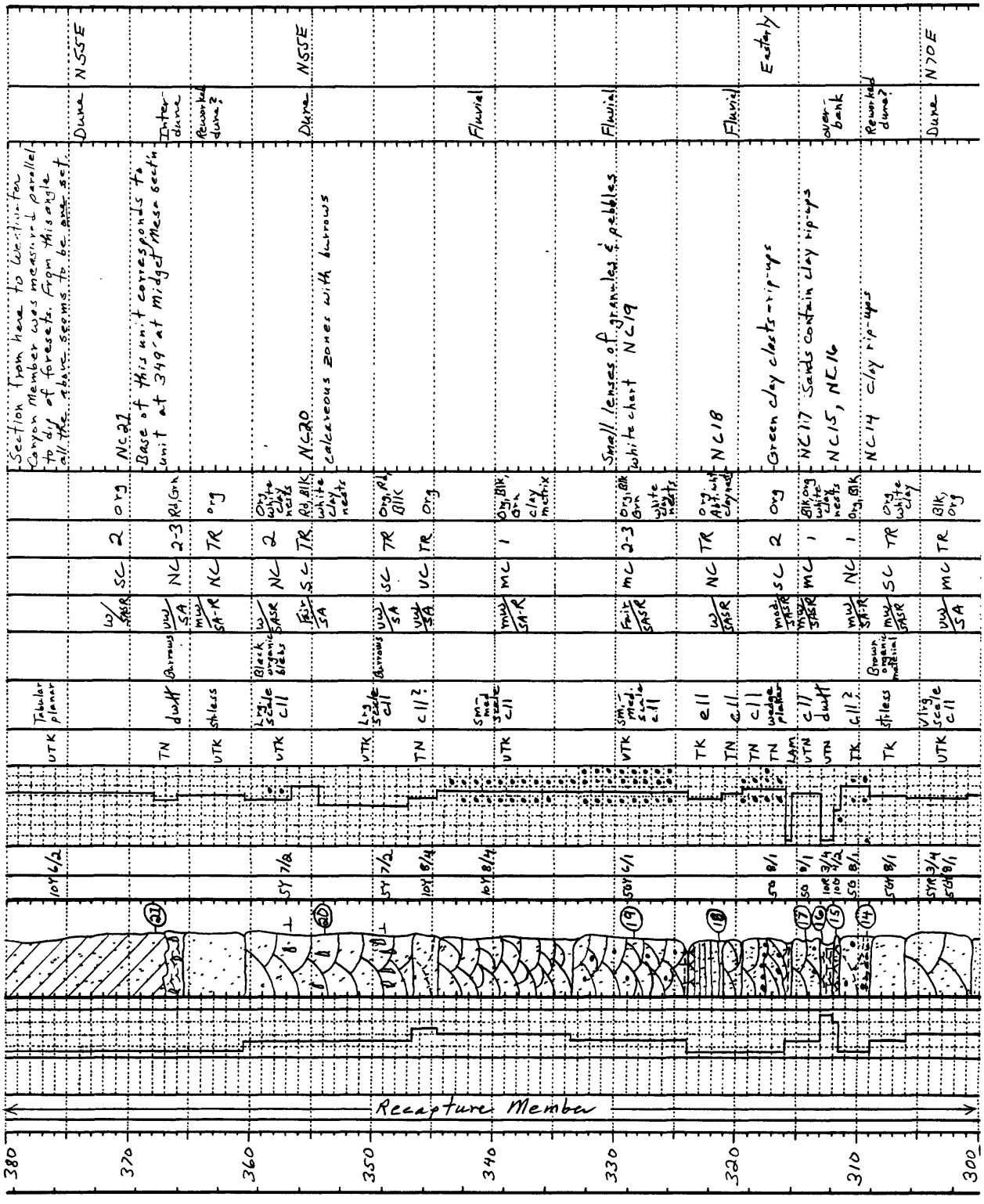
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Navajo Church Sec. 2, 11 T. 15N R. 17 W.

STATE ..... COUNTY .....

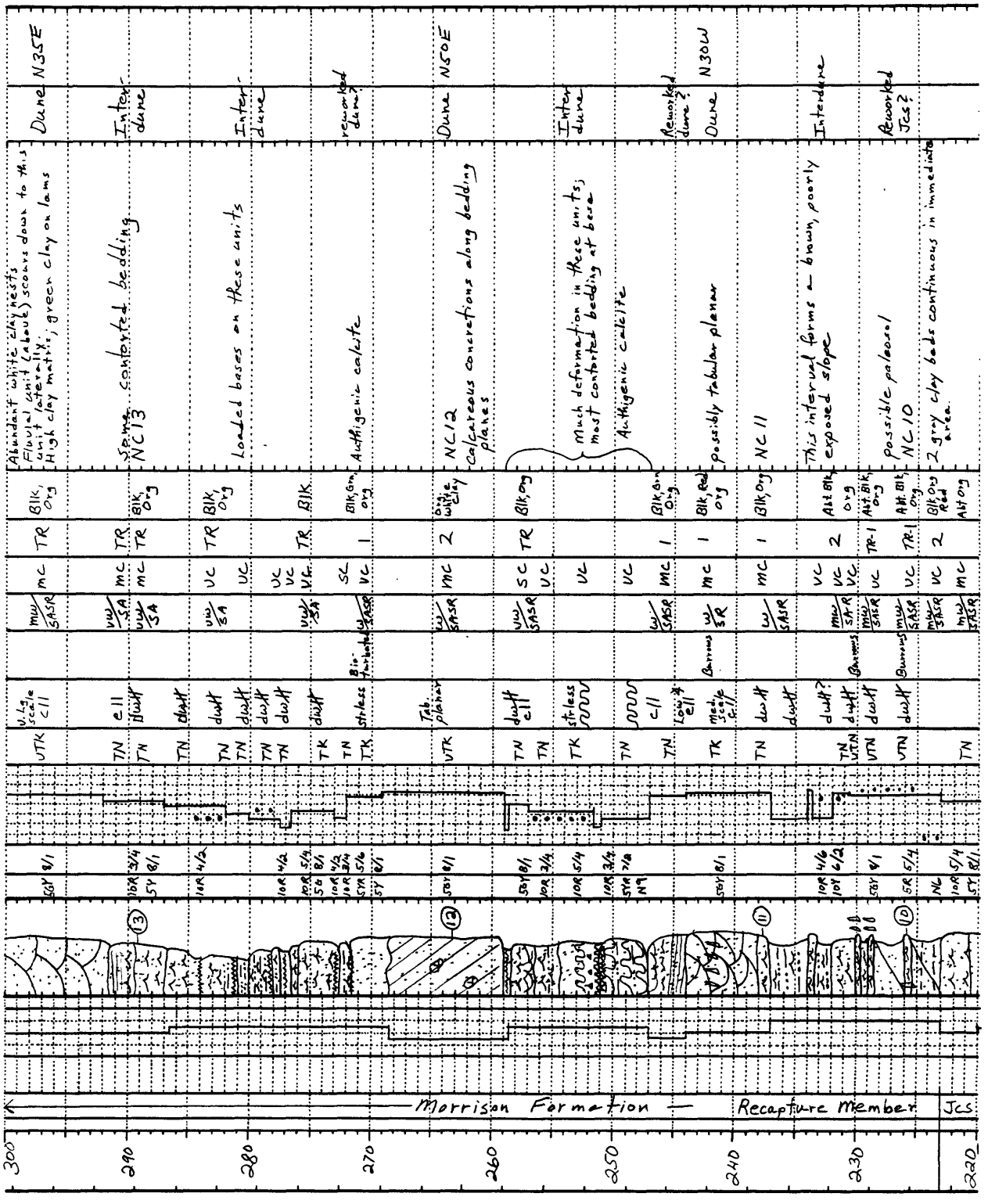
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Navajo Church Sec. 2, 11 T. 15N. R. 17W

STATE ..... COUNTY .....

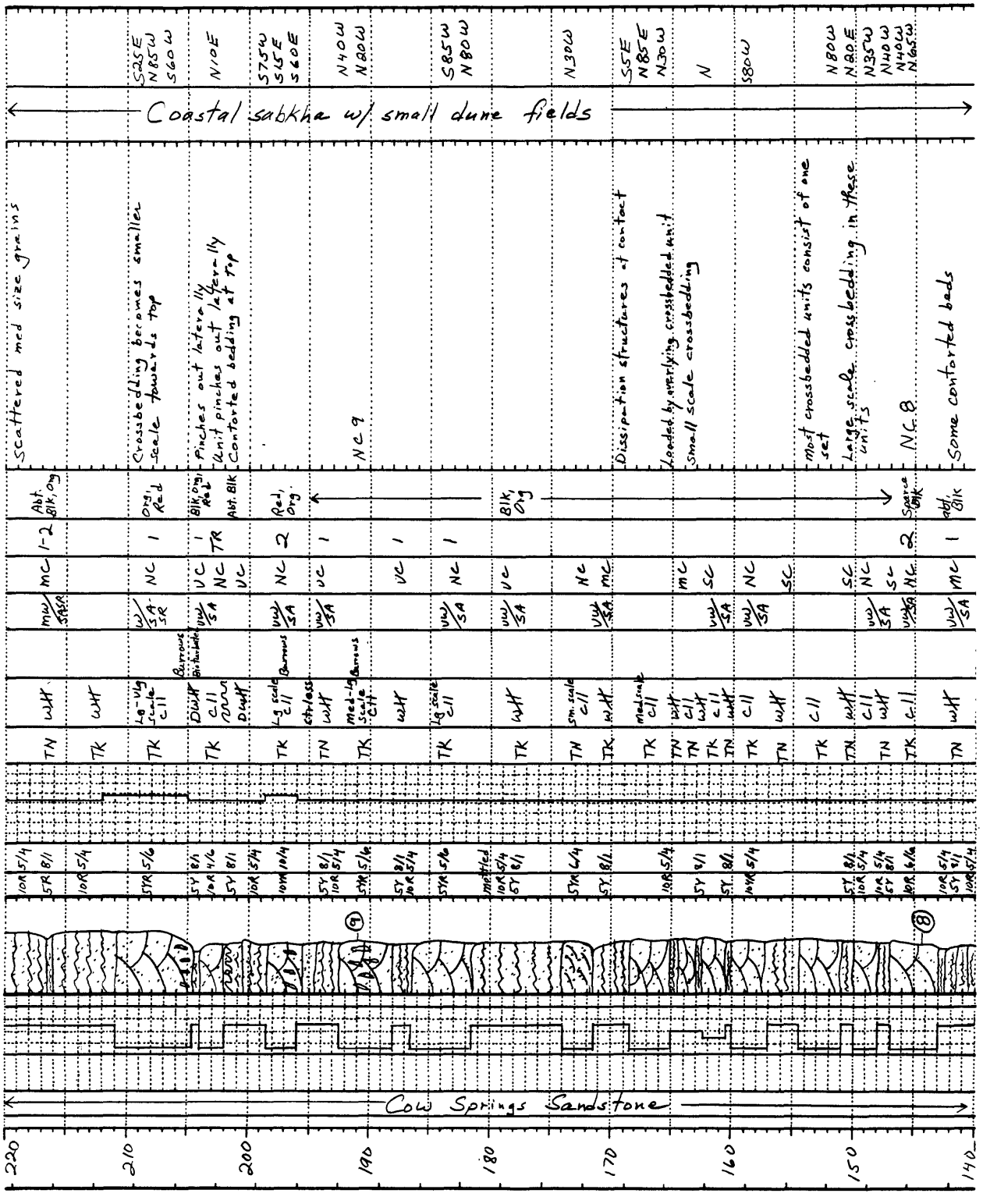
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Navajo Church Sec. 2, 11 T. 15N. R. 17W.

STATE ..... COUNTY .....

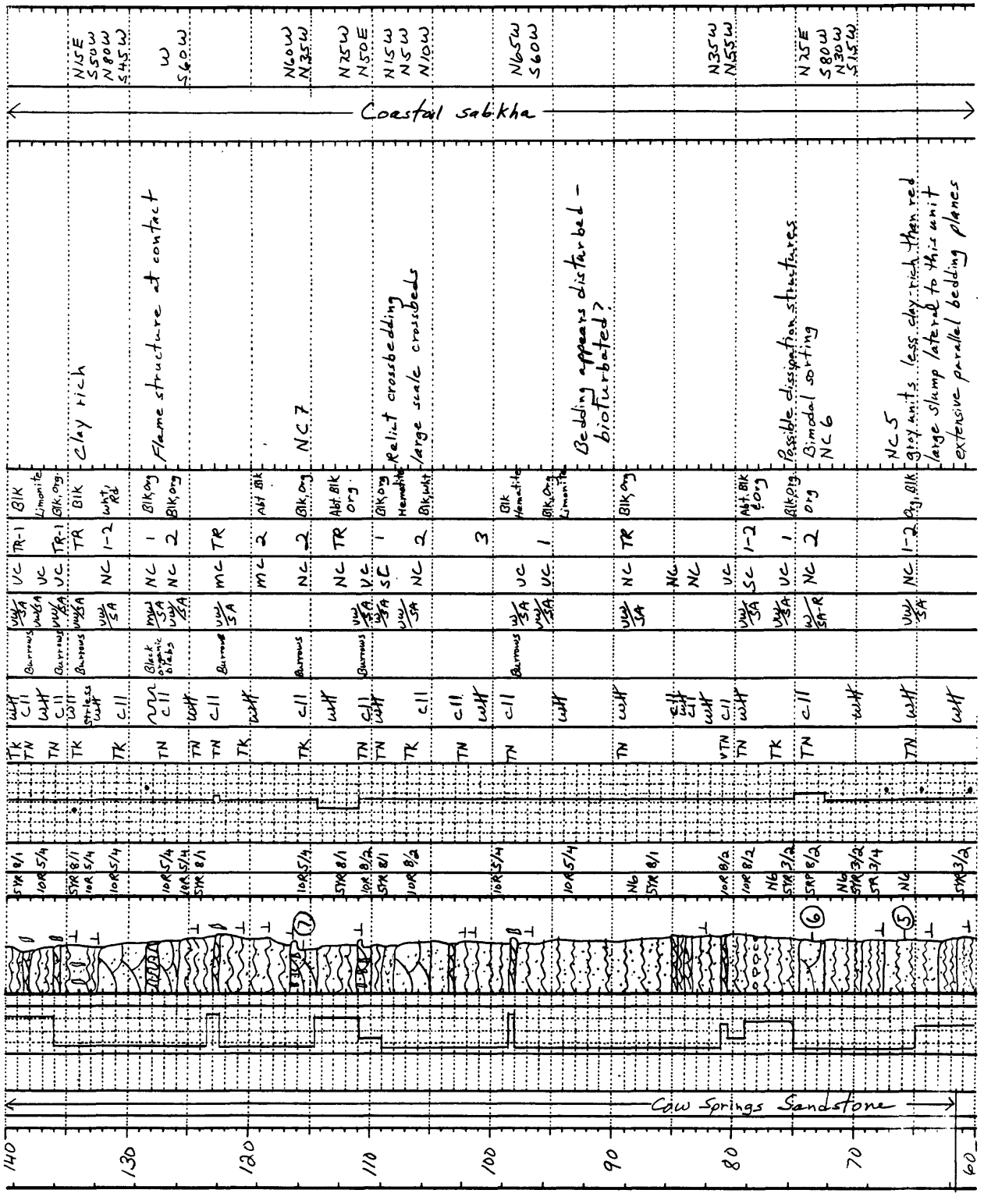
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Navajo Church Sec. 2, 11 T. 15 N. R. 17 W.

STATE ..... COUNTY .....

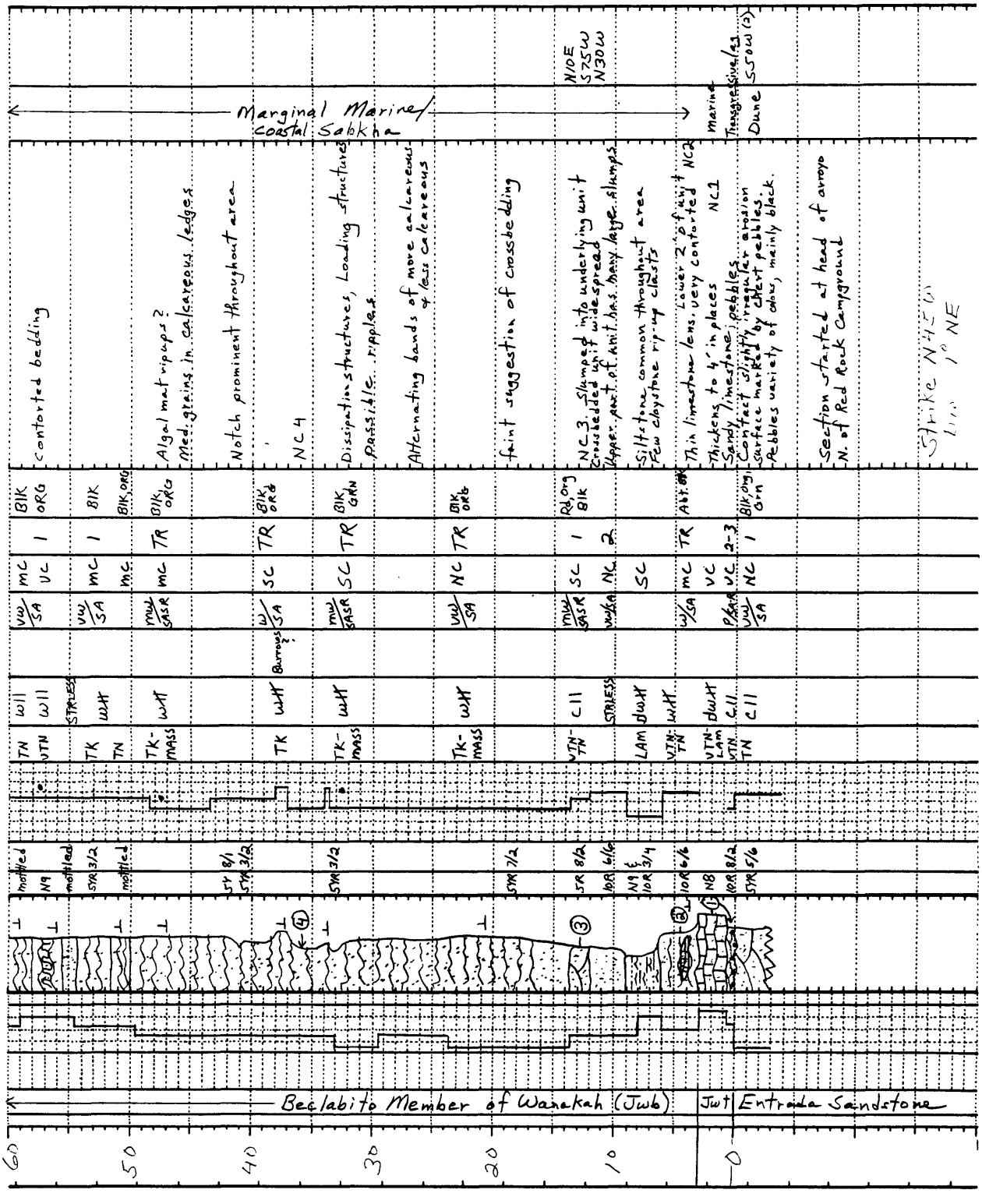
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Navajo Church Sec. SE¼ Sec. 2 NE¼ Sec. 11 T. 15 N. R. 17 W.

STATE New Mexico COUNTY McKinley

U.S.G.S. CORE LIBRARY NUMBER 7/9-7/11 1984 API WELL NUMBER Condon Pool



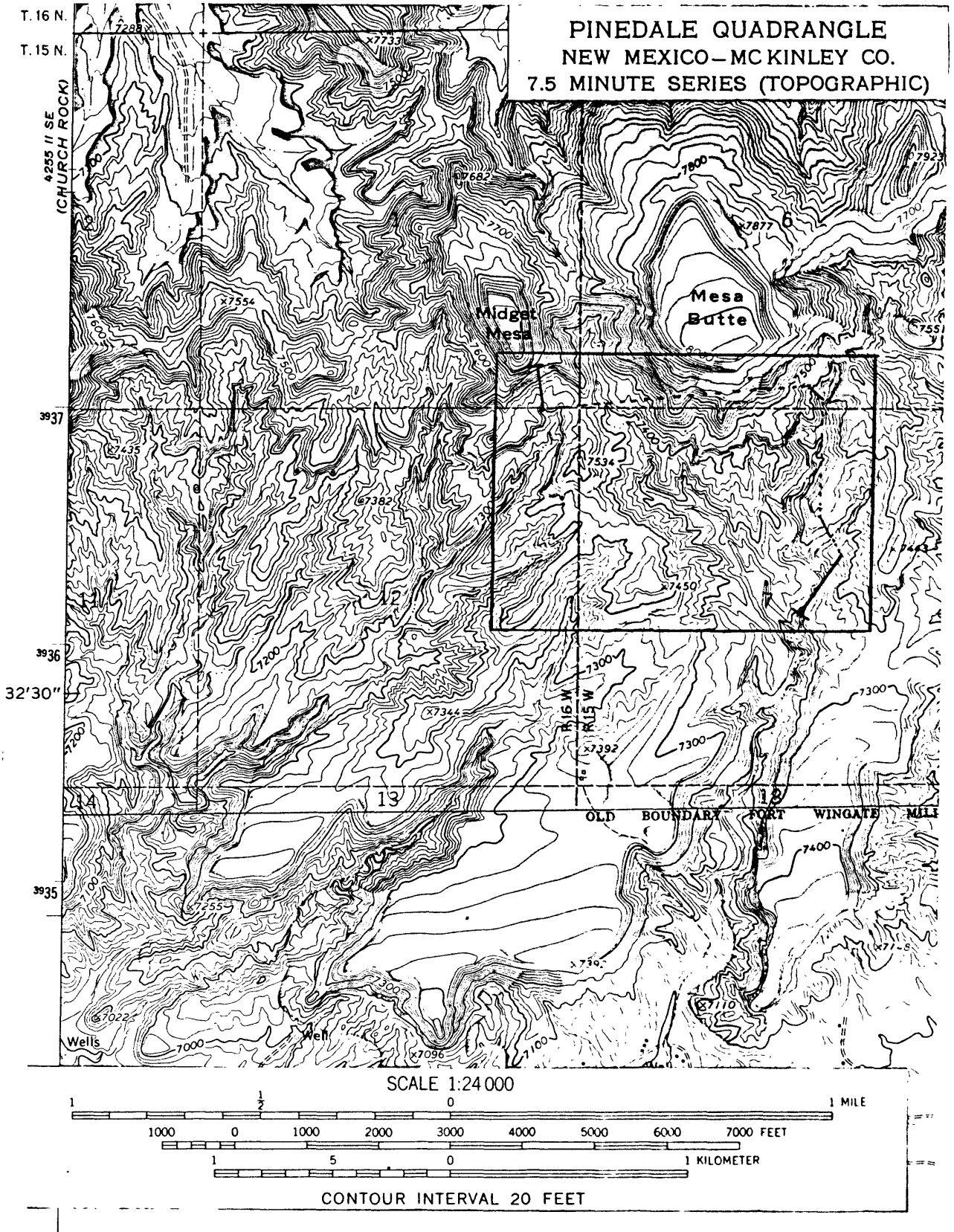


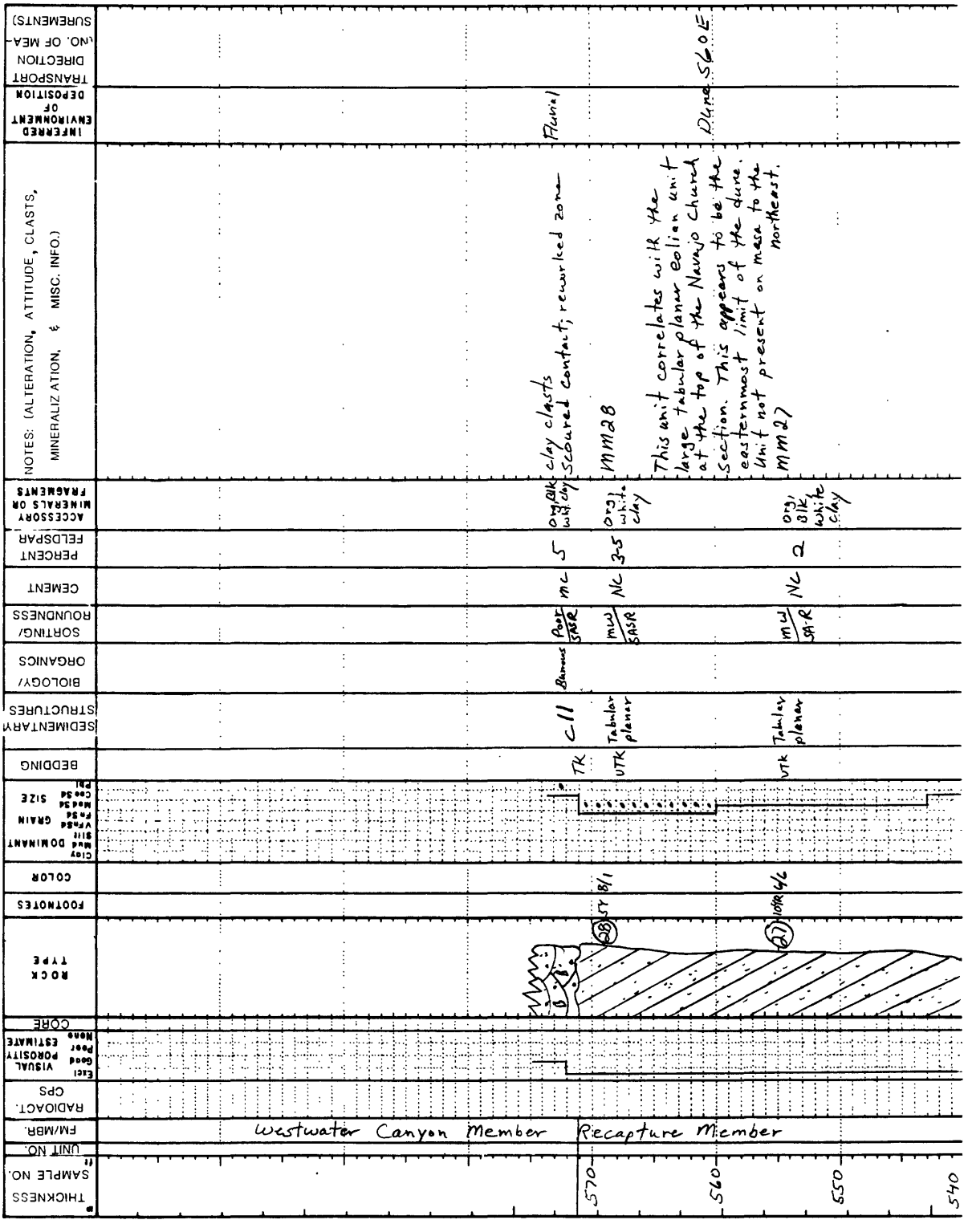
Figure 5. Location of Midget Mesa section.

STRATIGRAPHIC SECTION DESCRIPTION (STRAT. INTERVAL Je ..... TO Jmw .....)

2. LOCATION Midget Mesa SE¼ Sec. 1, T 15N, R. 16W SE¼ Sec. 6 T. 15N. R. 15W QUADRANGLE (7.5') Pinedale

STATE New Mexico COUNTY Mckinley DATE 7/12-7/14/1984

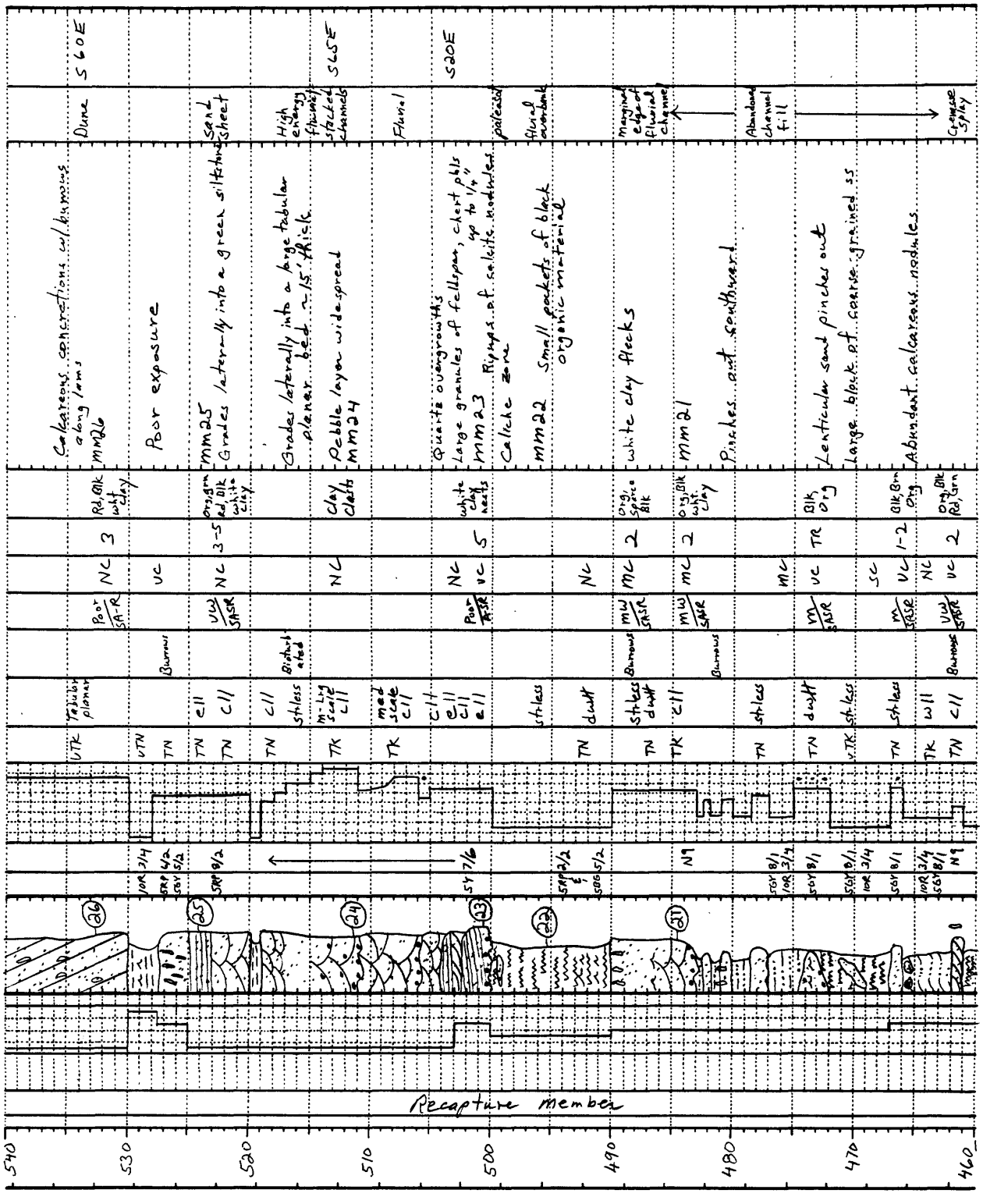
LAT.-LONG. GEOL. Condon, Pool



LOCATION Midget Mesa Sec. 1, 6, 7 T. 15N R. 15, 16 W

STATE ..... COUNTY .....

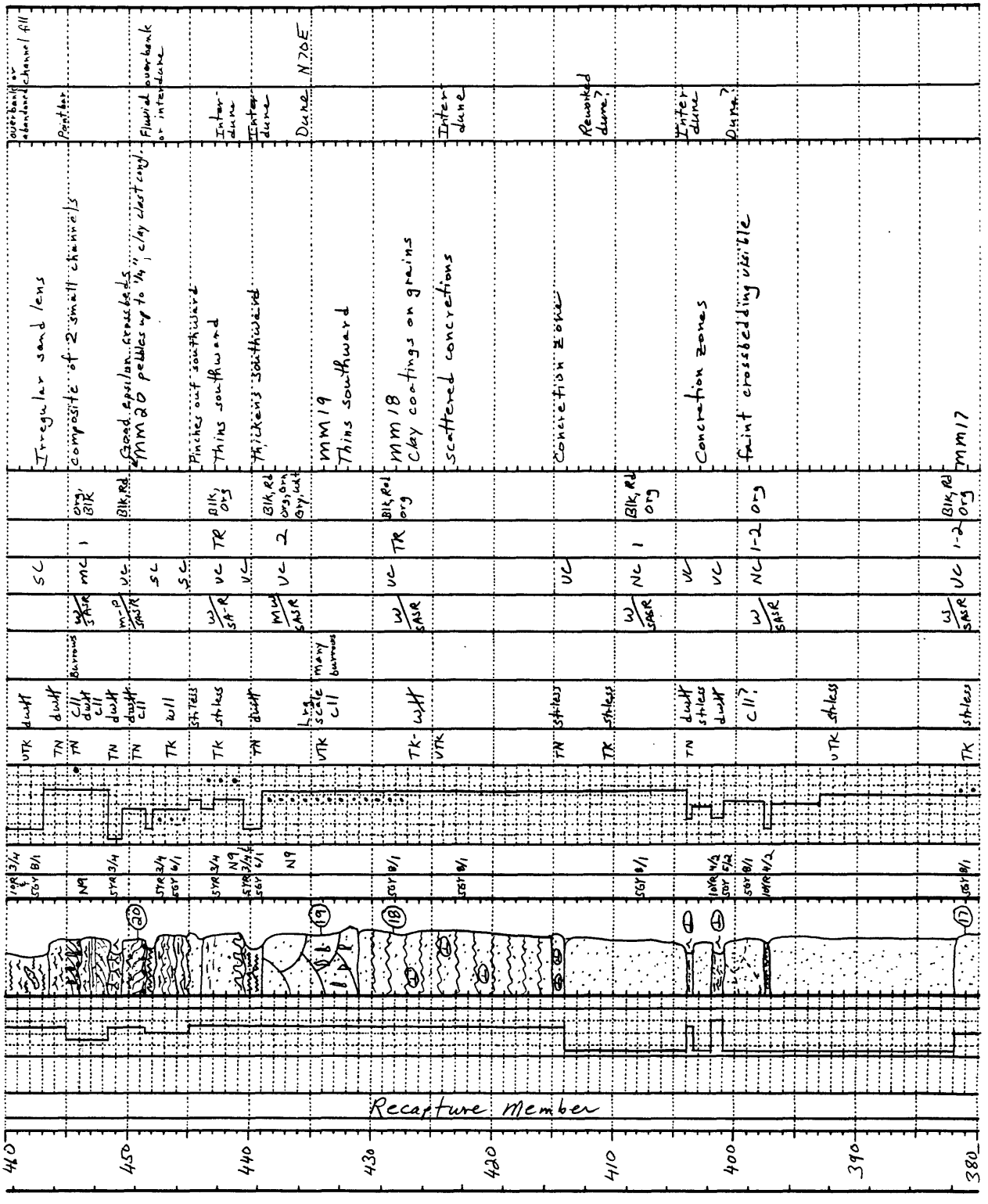
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Midget Mesa Sec. 1, 6, 7 T. 15N R. 15, 16 W

STATE ..... COUNTY .....

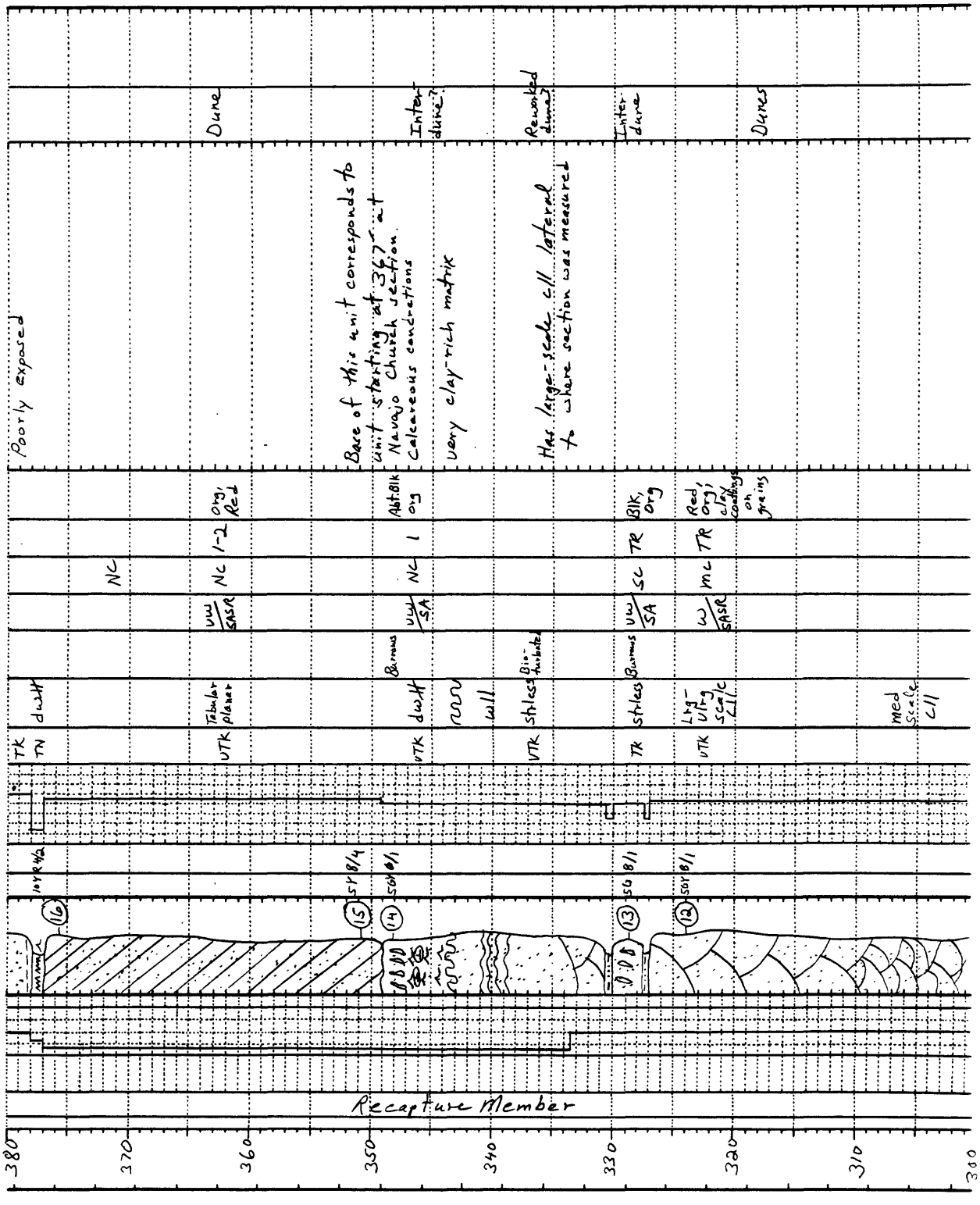
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Midget Mesa Sec. 1, 6, 7 T. 15N R. 15, 16 W

STATE COUNTY

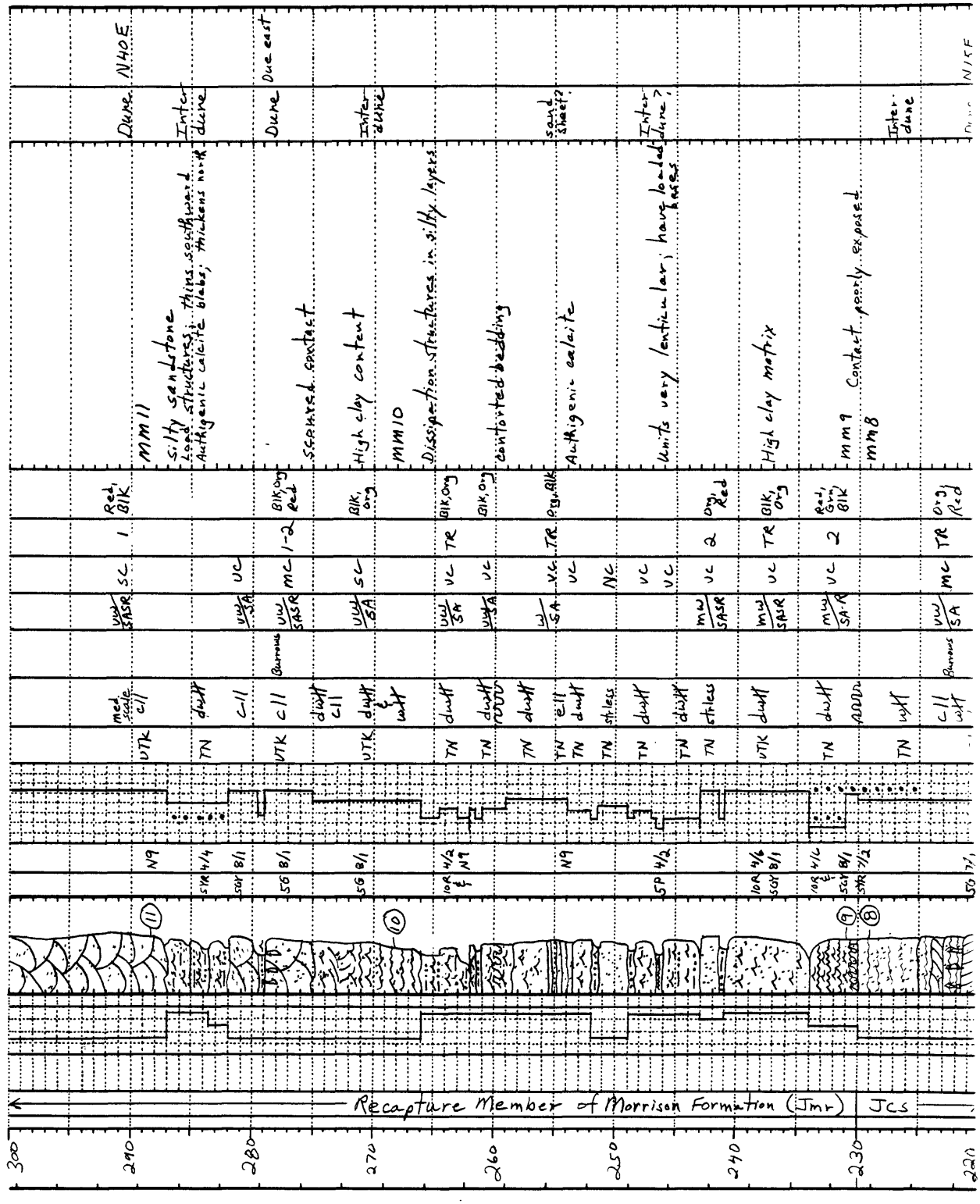
U.S.G.S. CORE LIBRARY NUMBER API WELL NUMBER



LOCATION Midget Mesa Sec. 1, 6, 7 T. 15N R. 15, 16 W

STATE ..... COUNTY .....

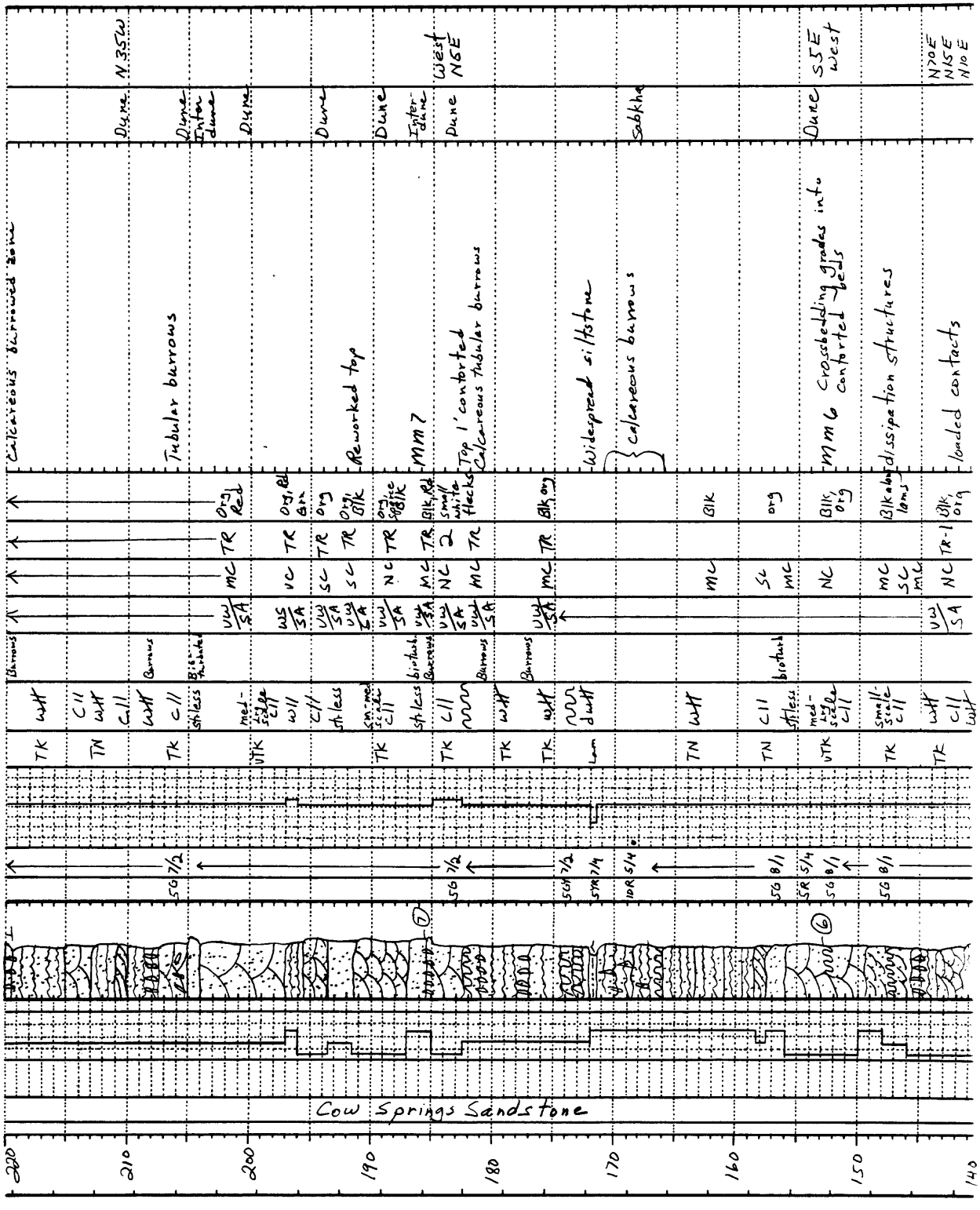
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Midget Mesa Sec. 1, 6, 7 T. 15N R. 15, 16 W

STATE ..... COUNTY .....

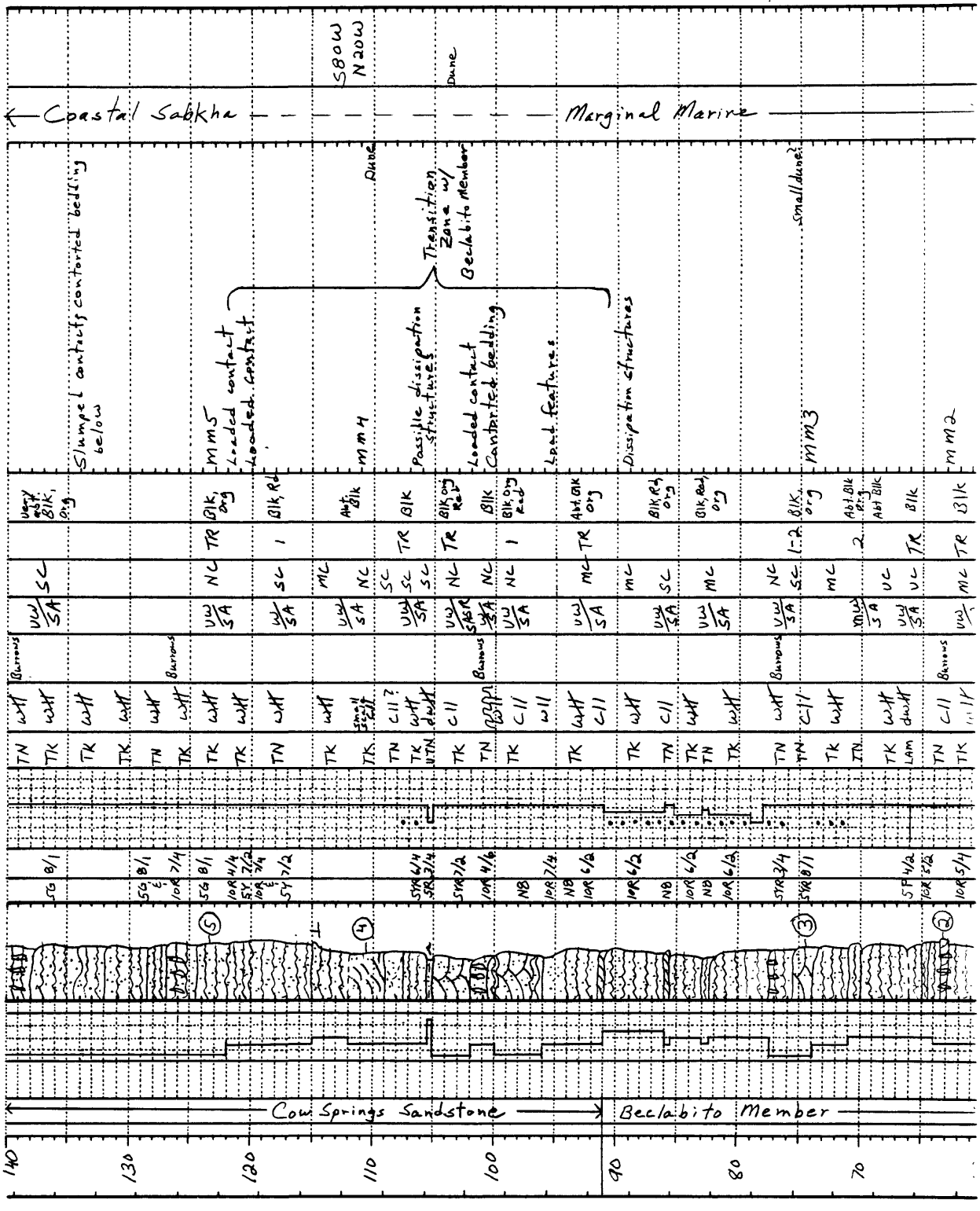
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Midget Mesa Sec. 1, 6, 7 T. 15N R. 15, 16 W

STATE COUNTY

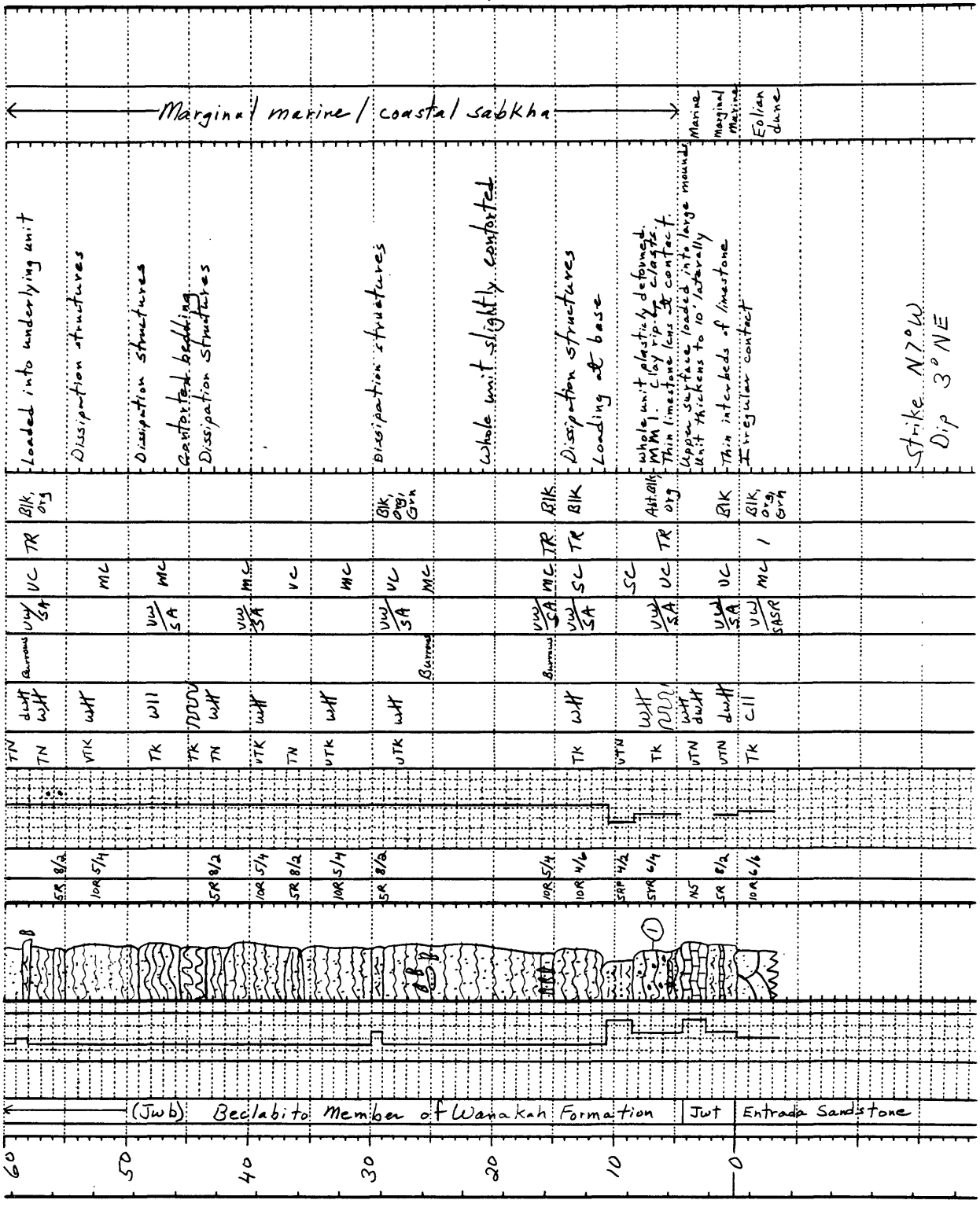
U.S.G.S. CORE LIBRARY NUMBER API WELL NUMBER



LOCATION Midget Mesa Sec. SE¼Sec. 1, SE¼Sec. 6, N½ Sec. 7 T. 15N R. 15, 16 W

STATE New Mexico COUNTY McKinley

U.S.G.S. CORE LIBRARY NUMBER 7/12 - 7/14, 1984 API WELL NUMBER Condon, Pool



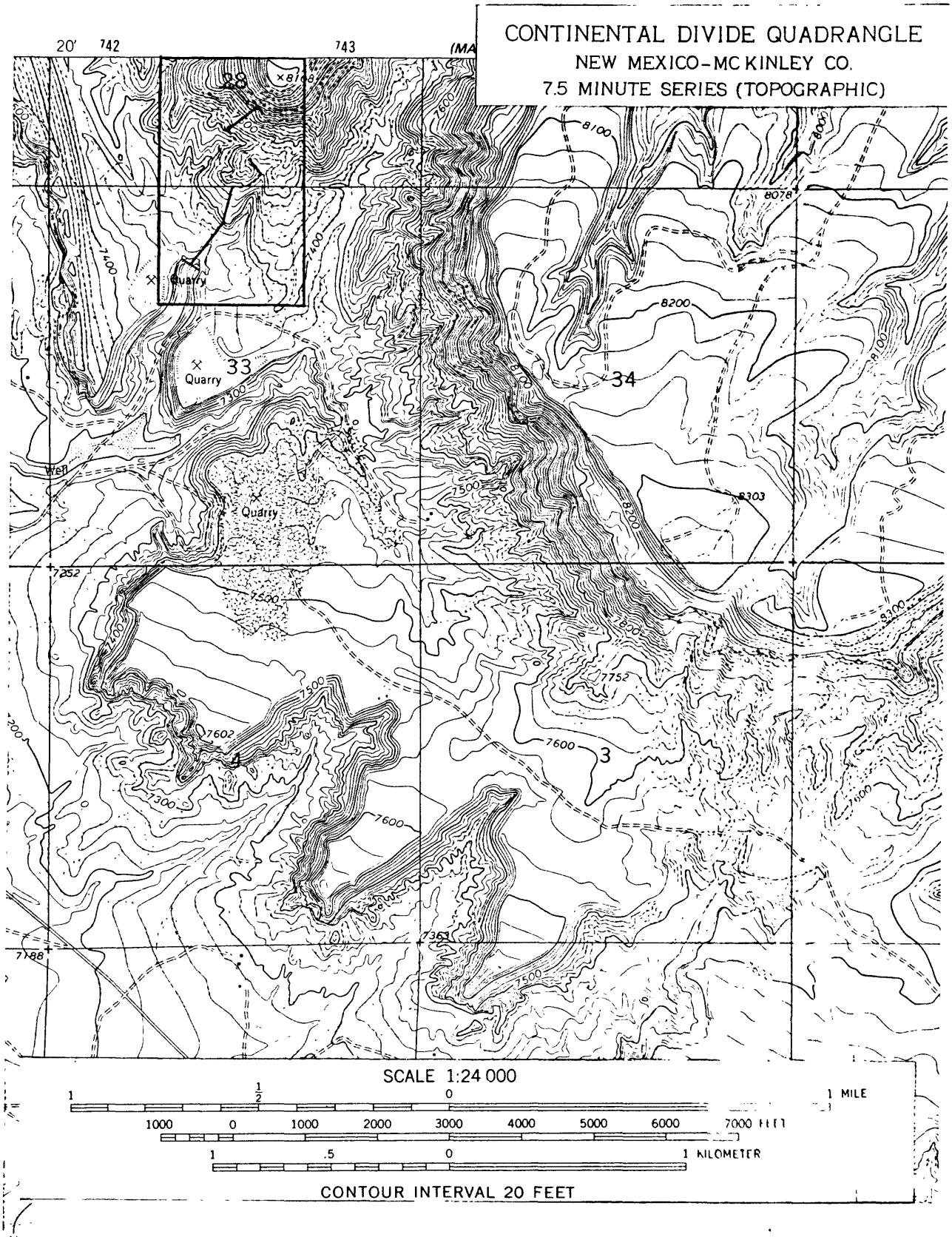


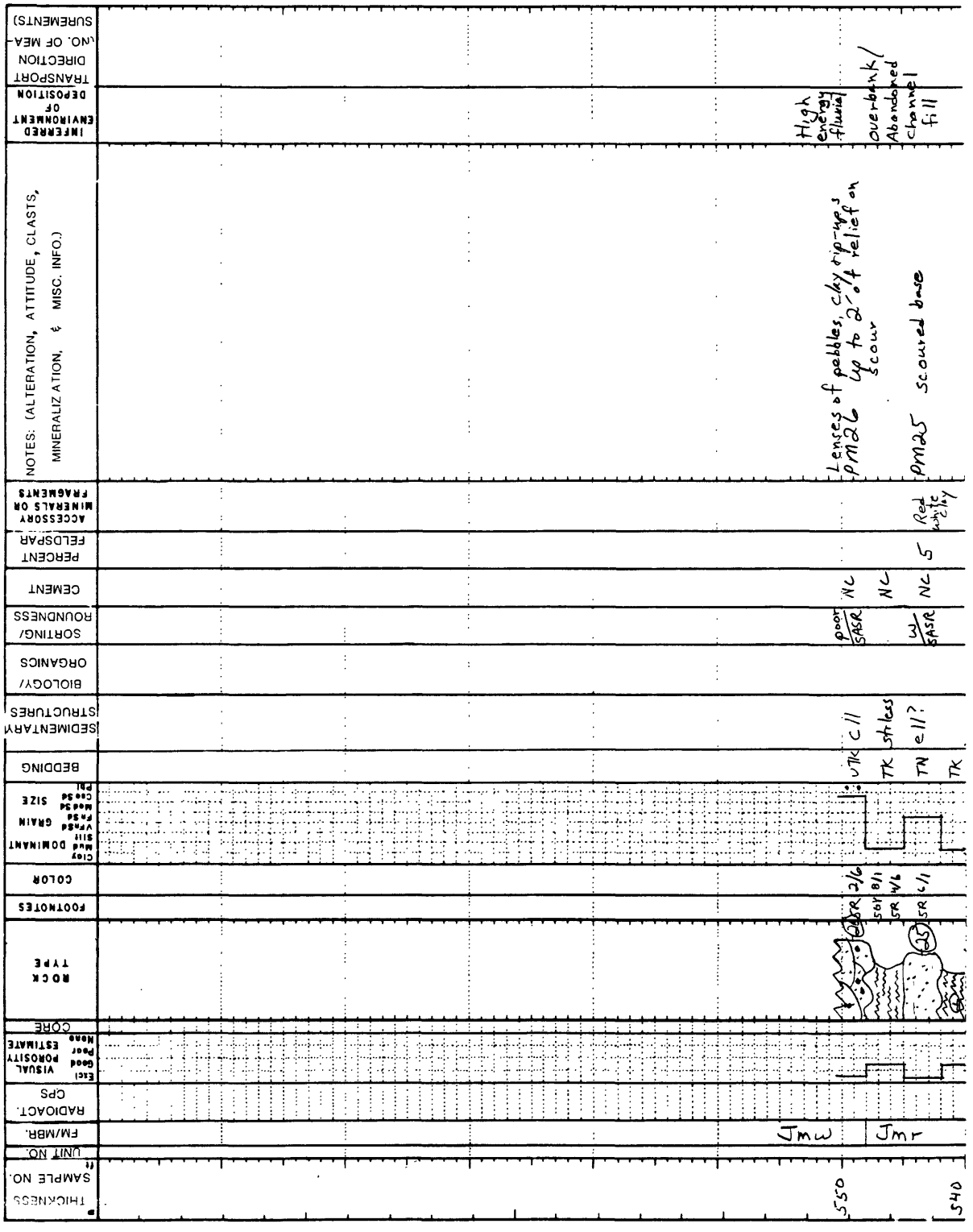
Figure 6. Location of Pinedale Monocline section.

3 LOCATION Pinedale Monocline Sec. 28 33 T. 15N R. 14W QUADRANGLE (7.5') Continental Divide

STATE New Mexico COUNTY McKinley DATE 7/17-7/18, 1984

LAT.-LONG. GEOL. Condon, Peel

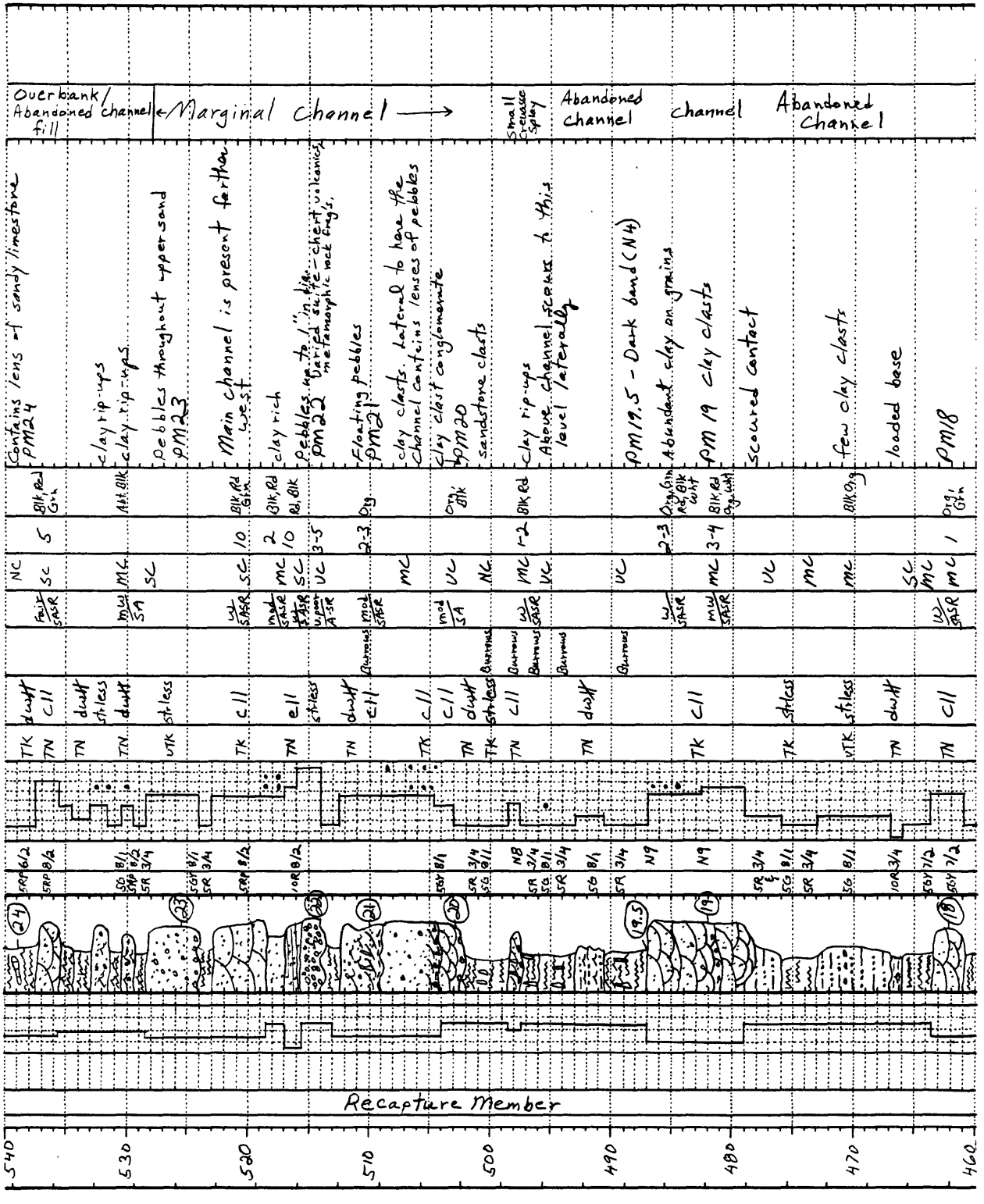
STRATIGRAPHIC SECTION DESCRIPTION (STRAT. INTERVAL Je.....TO Jmw)



LOCATION Pinedale Monocline Sec. 28, 33 T. 15N. R. 14W.

STATE ..... COUNTY .....

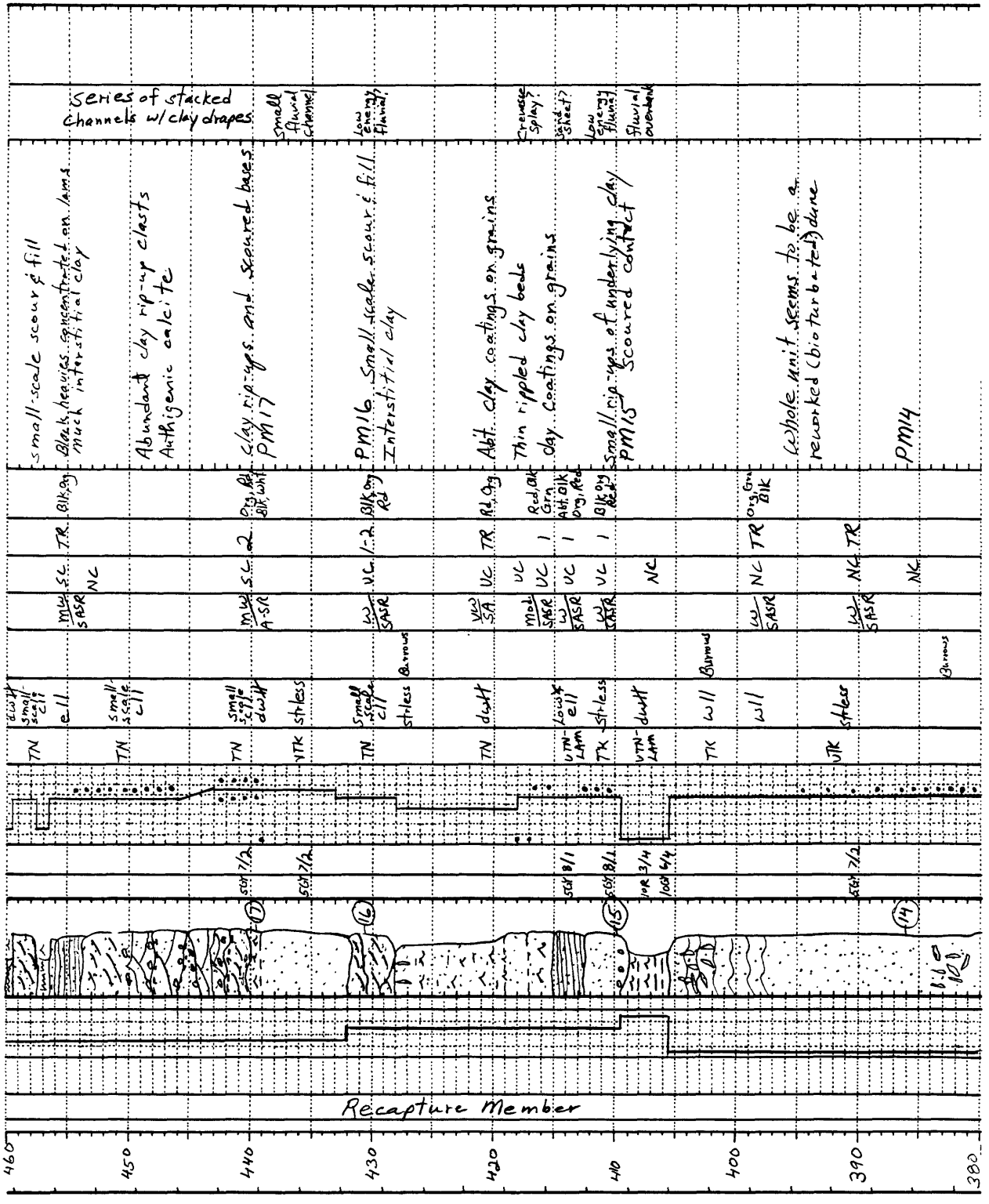
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Pinedale Meneline Sec. 28, 33 T. 15N R. 14W

STATE ..... COUNTY .....

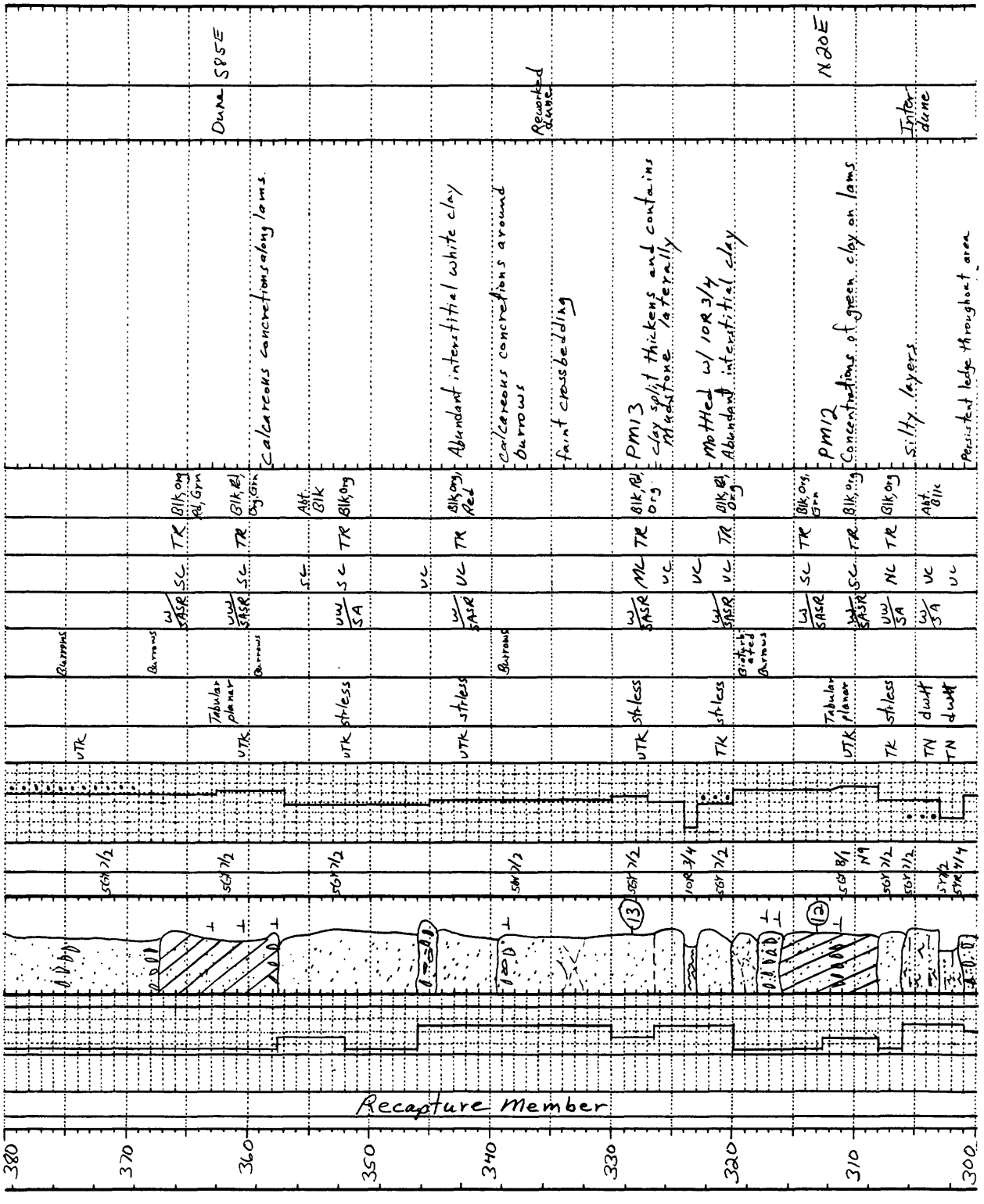
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Pinedale Monocline Sec. 28, 33 T. 15N R. 14W

STATE COUNTY

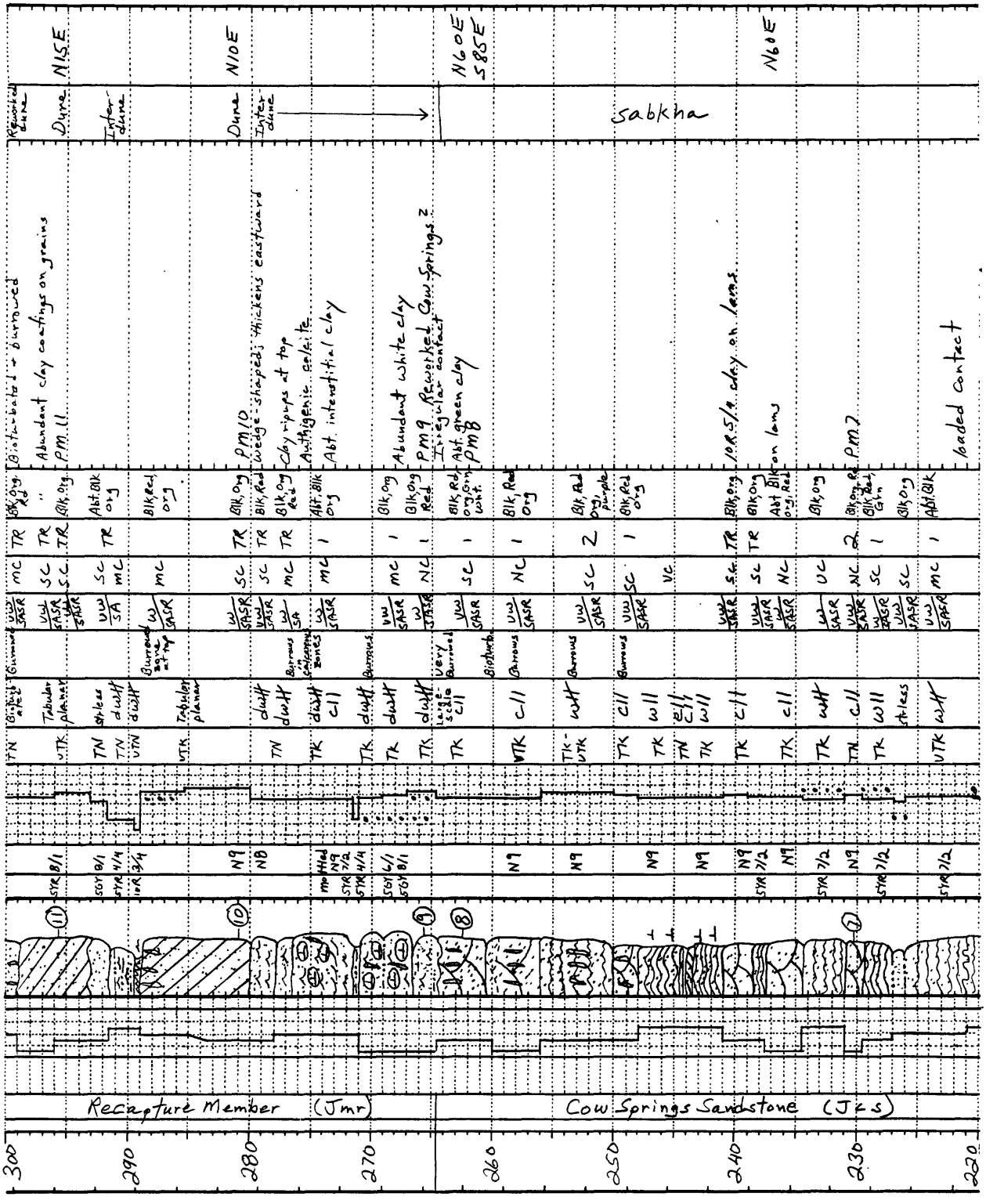
U.S.G.S. CORE LIBRARY NUMBER API WELL NUMBER



LOCATION Pinedale Monocline Sec. 28, 33 T. 15N R. 14W

STATE ..... COUNTY .....

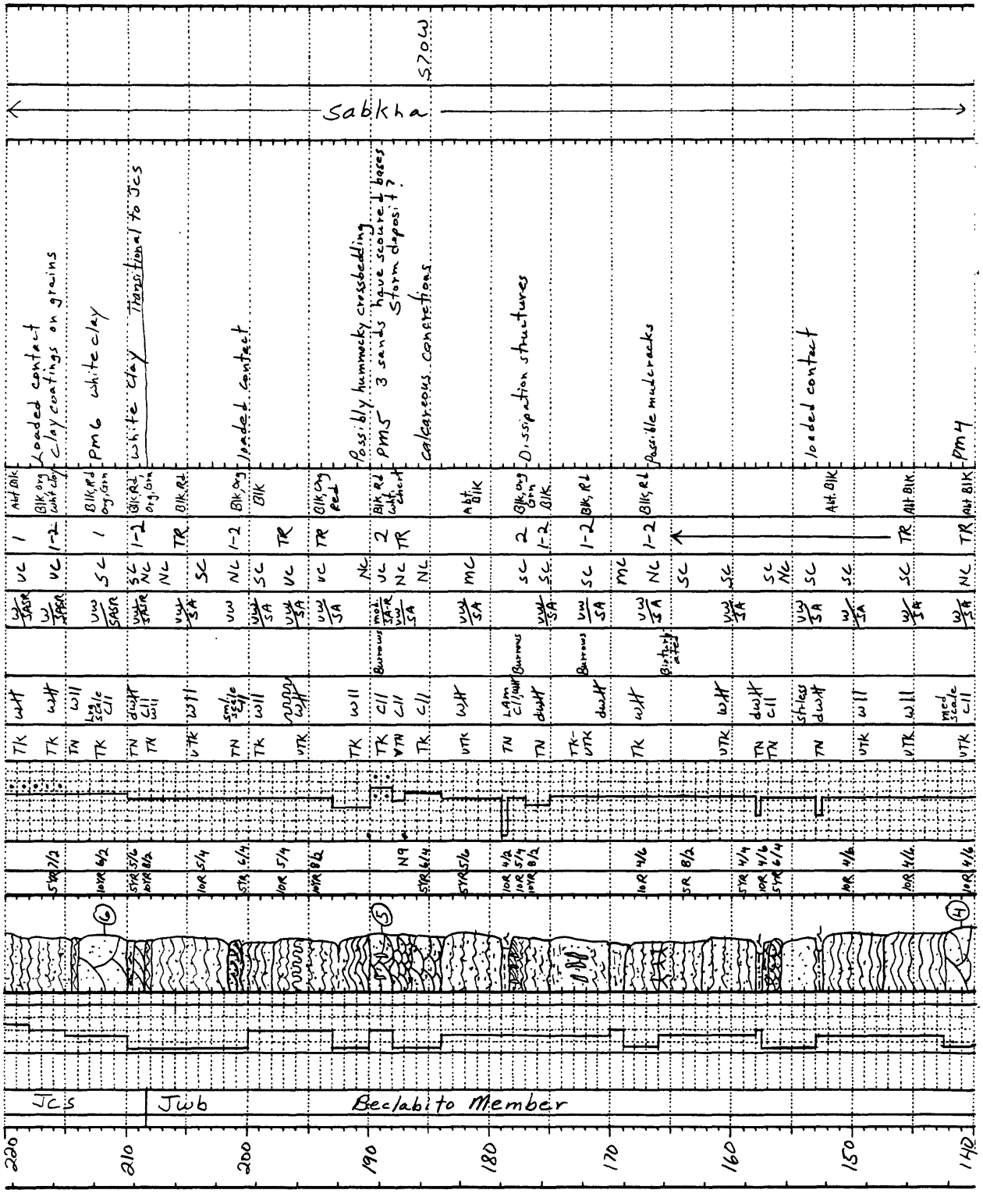
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Pinedale Monocline Sec. 28, 33 T. 15N R. 14W

STATE ..... COUNTY .....

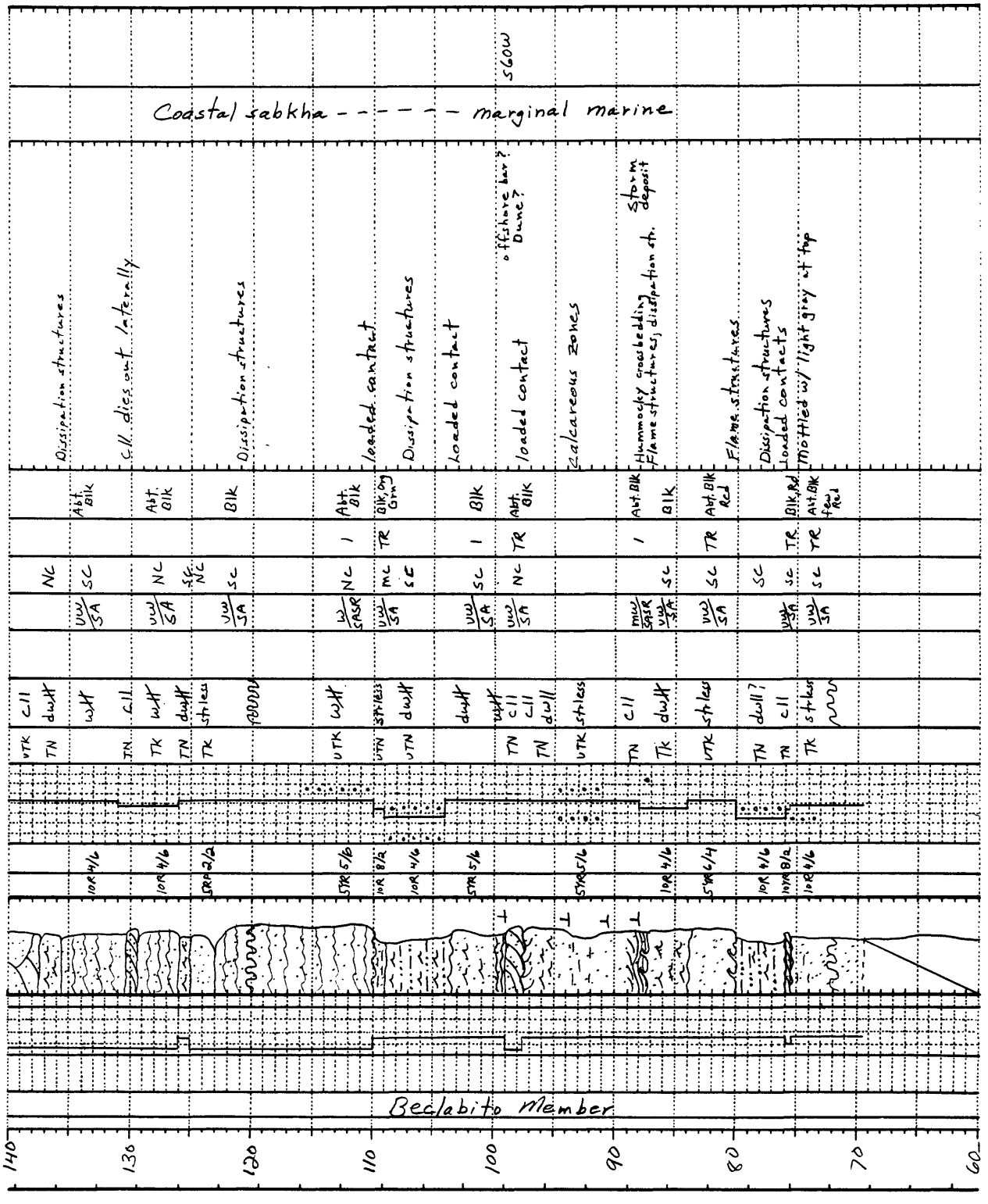
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Pinedale Monocline Sec. 28, 33 T. 15N R. 14W

STATE COUNTY

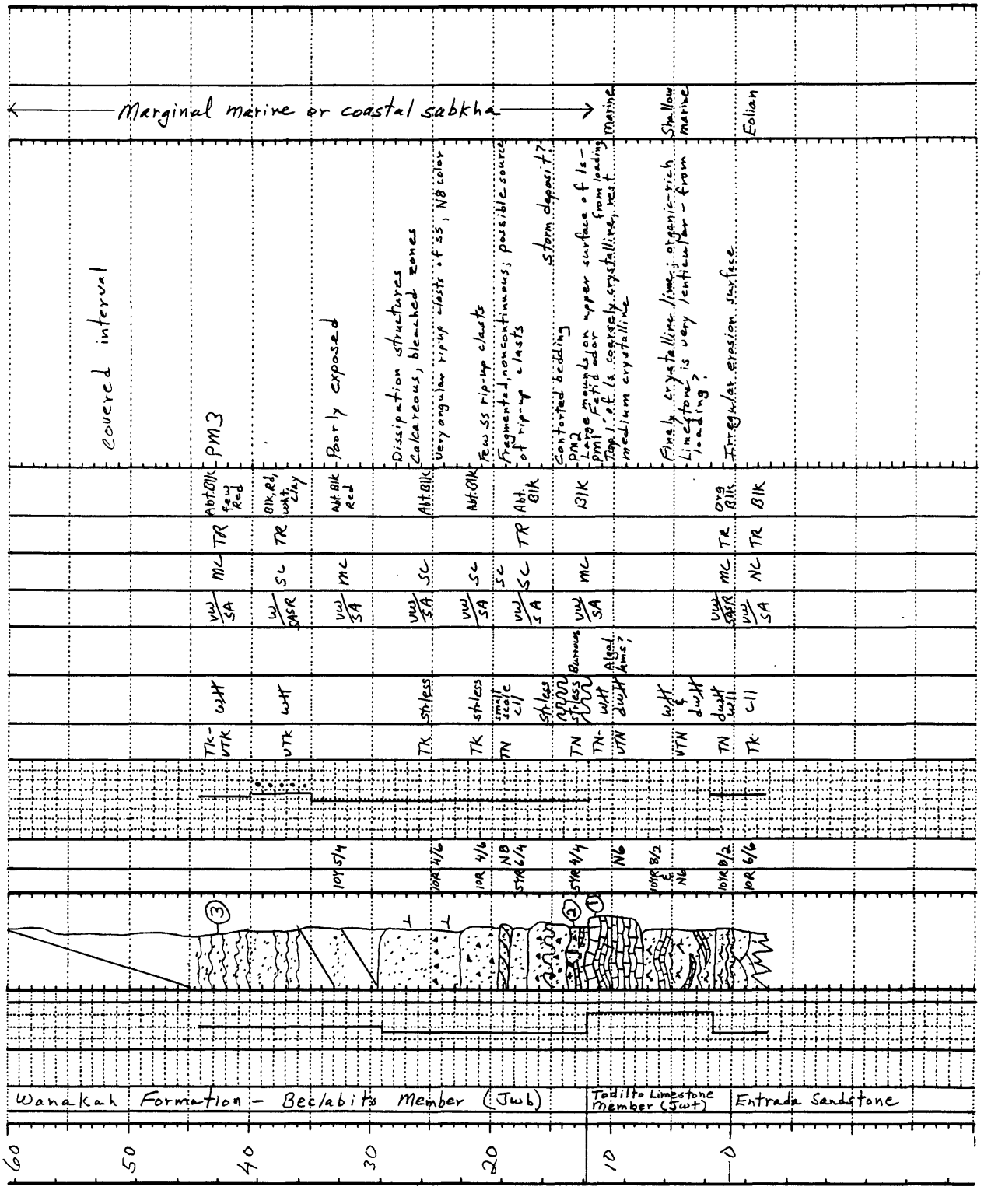
U.S.G.S. CORE LIBRARY NUMBER API WELL NUMBER



LOCATION Pinedale Monocline Sec. 28, 33 T. 15N R. 14W

STATE COUNTY

U.S.G.S. CORE LIBRARY NUMBER API WELL NUMBER



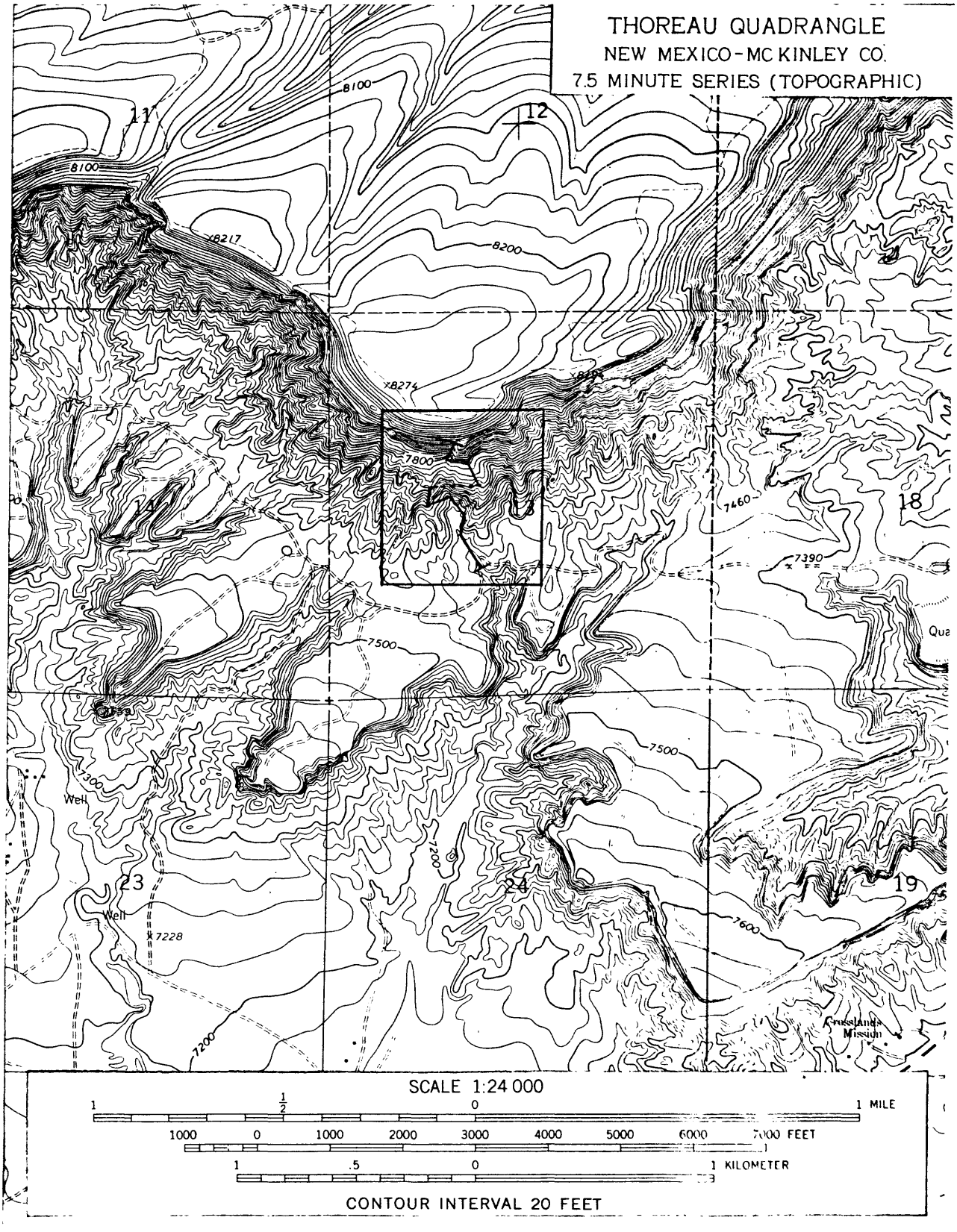


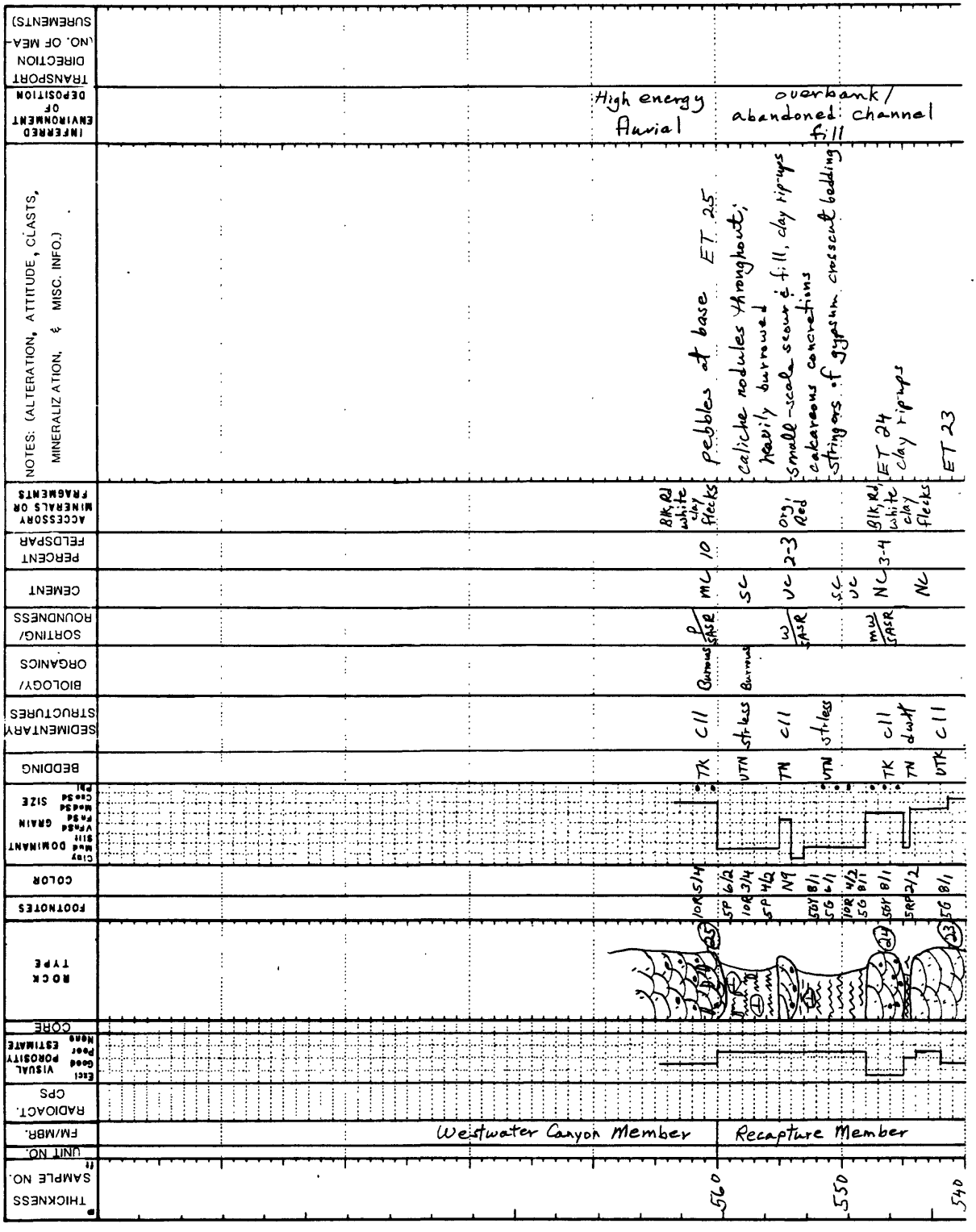
Figure 7. Location of East Thoreau section.

4. LOCATION East Thoreau Sec. W½ 13 T. 14N R. 13W QUADRANGLE (7.5') Thoreau

STATE New Mexico COUNTY McKinley DATE 7/19-7/21 1984

LAT.-LONG. GEOL. Condon, Pool

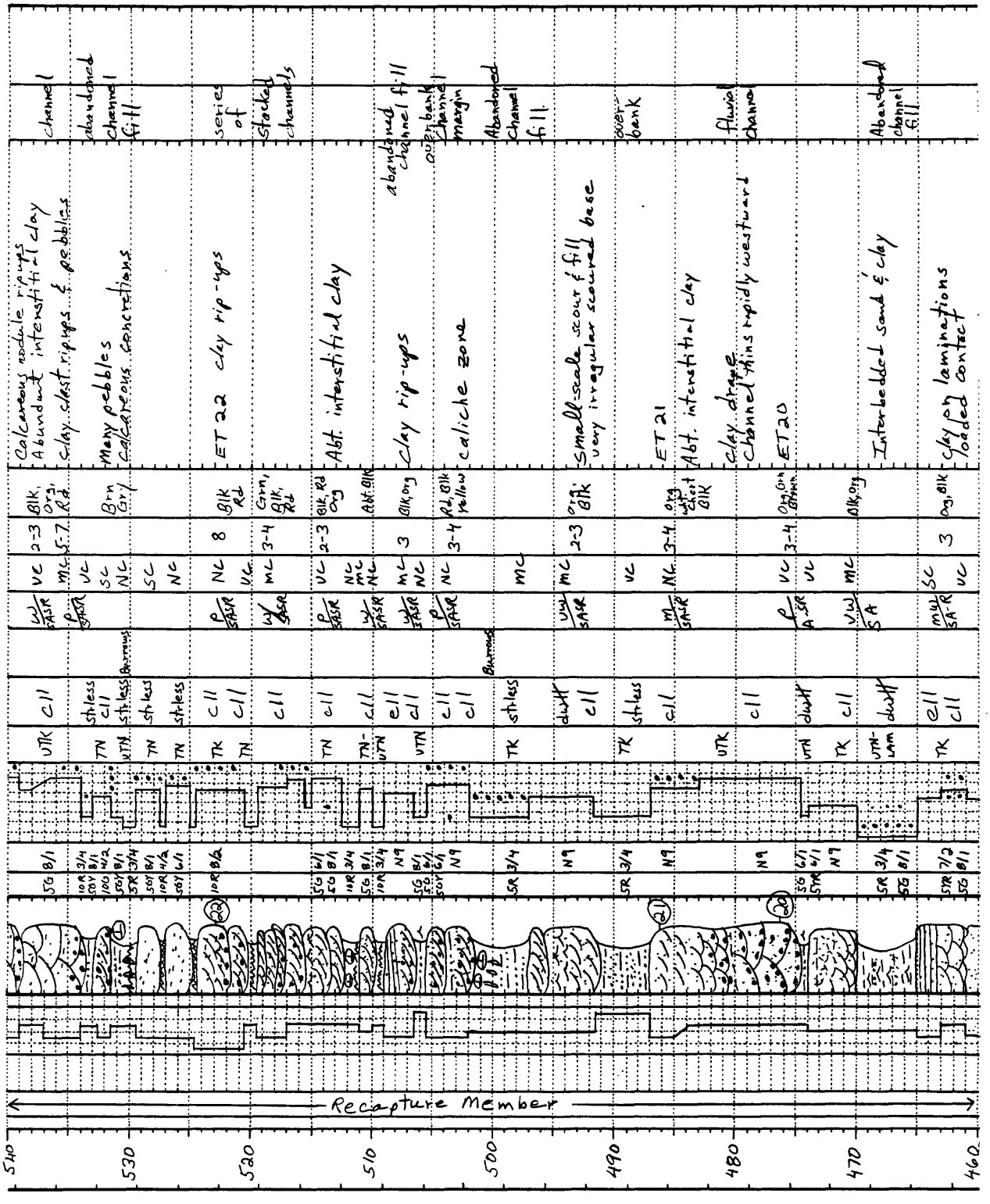
STRATIGRAPHIC SECTION DESCRIPTION (STRAT. INTERVAL Je ..... TO Jmh ...)



LOCATION East Thoreau Sec. W½ Sec. 13 T. 14 N. R. 13 W.

STATE ..... COUNTY .....

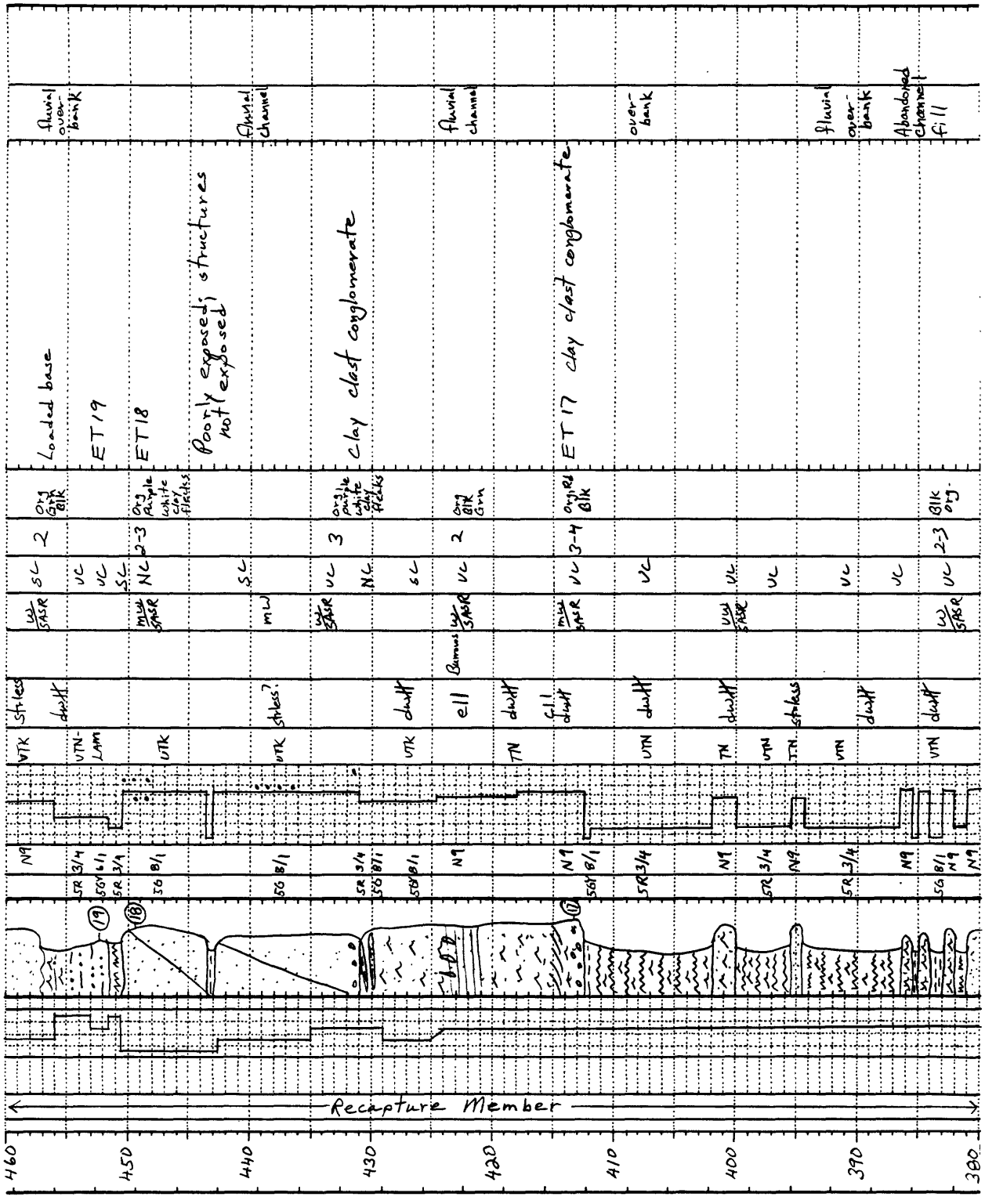
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION East Thoreau Sec. W½ Sec. 13 T. 14 N. R. 13 W

STATE ..... COUNTY .....

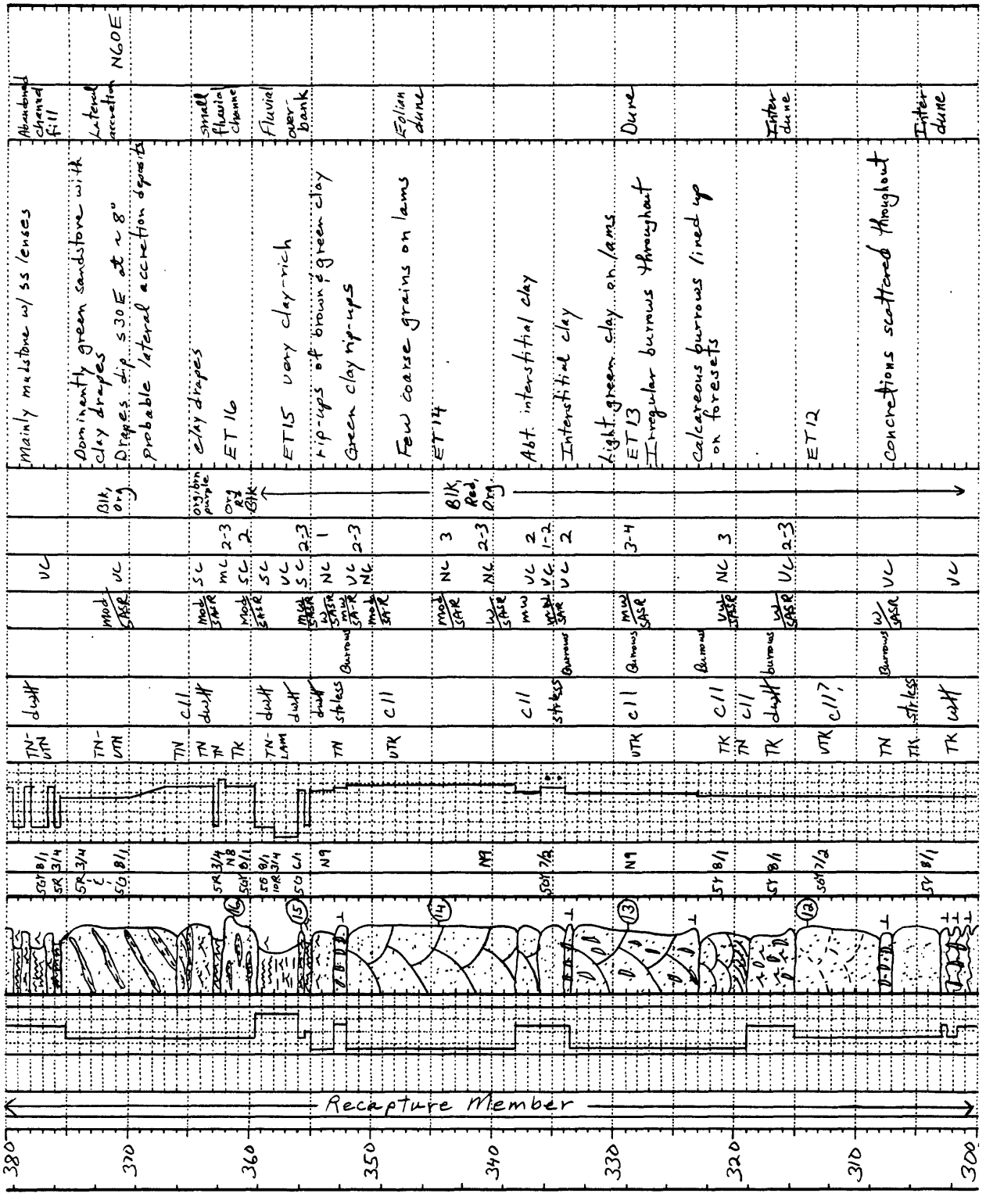
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION East Thoreau Sec. W 1/2 Sec. 13 T. 14 N. R. 13 W.

STATE ..... COUNTY .....

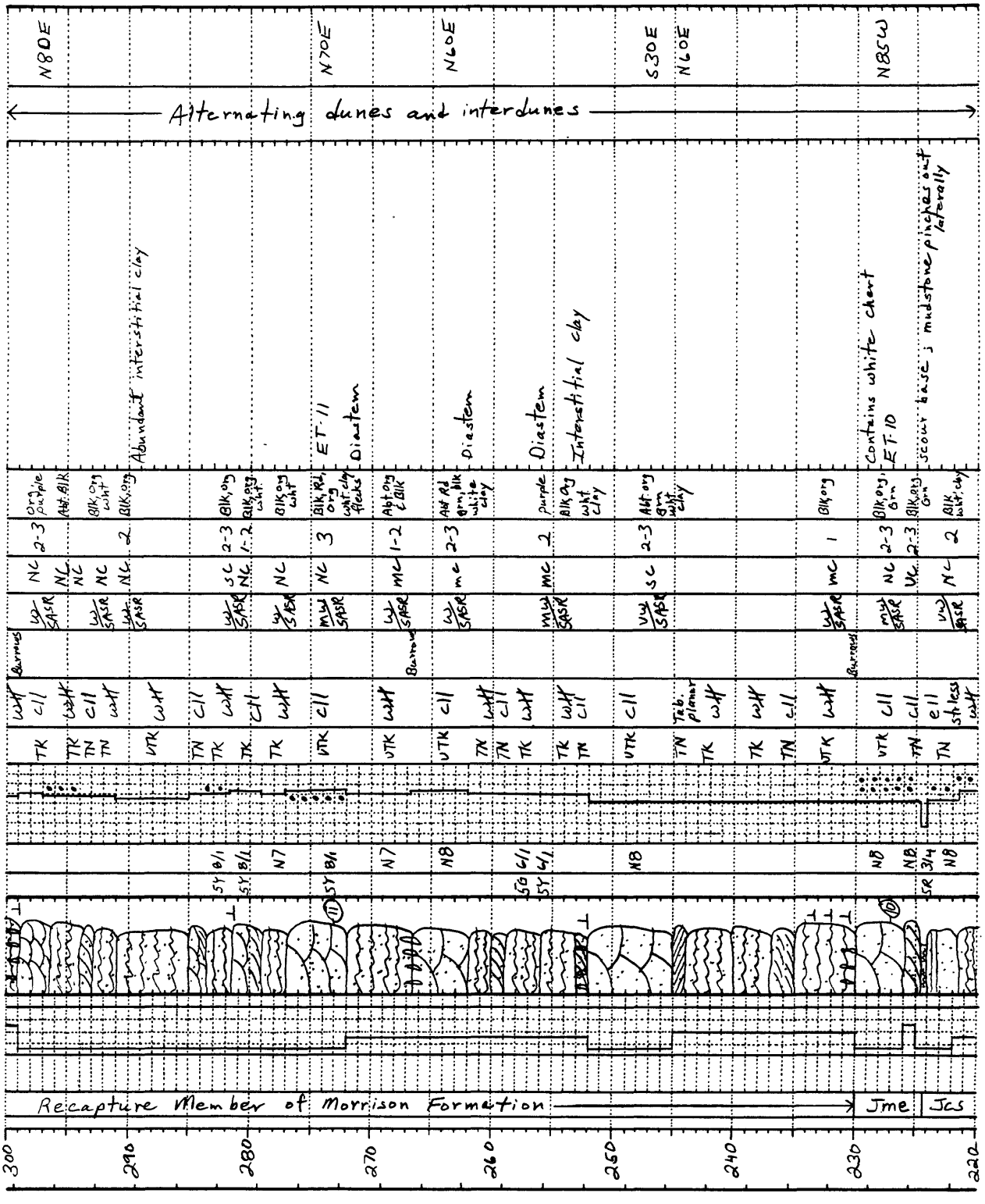
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION East Thoreau Sec. W½ Sec. 13 T. 14 N. R. 13 W.

STATE ..... COUNTY .....

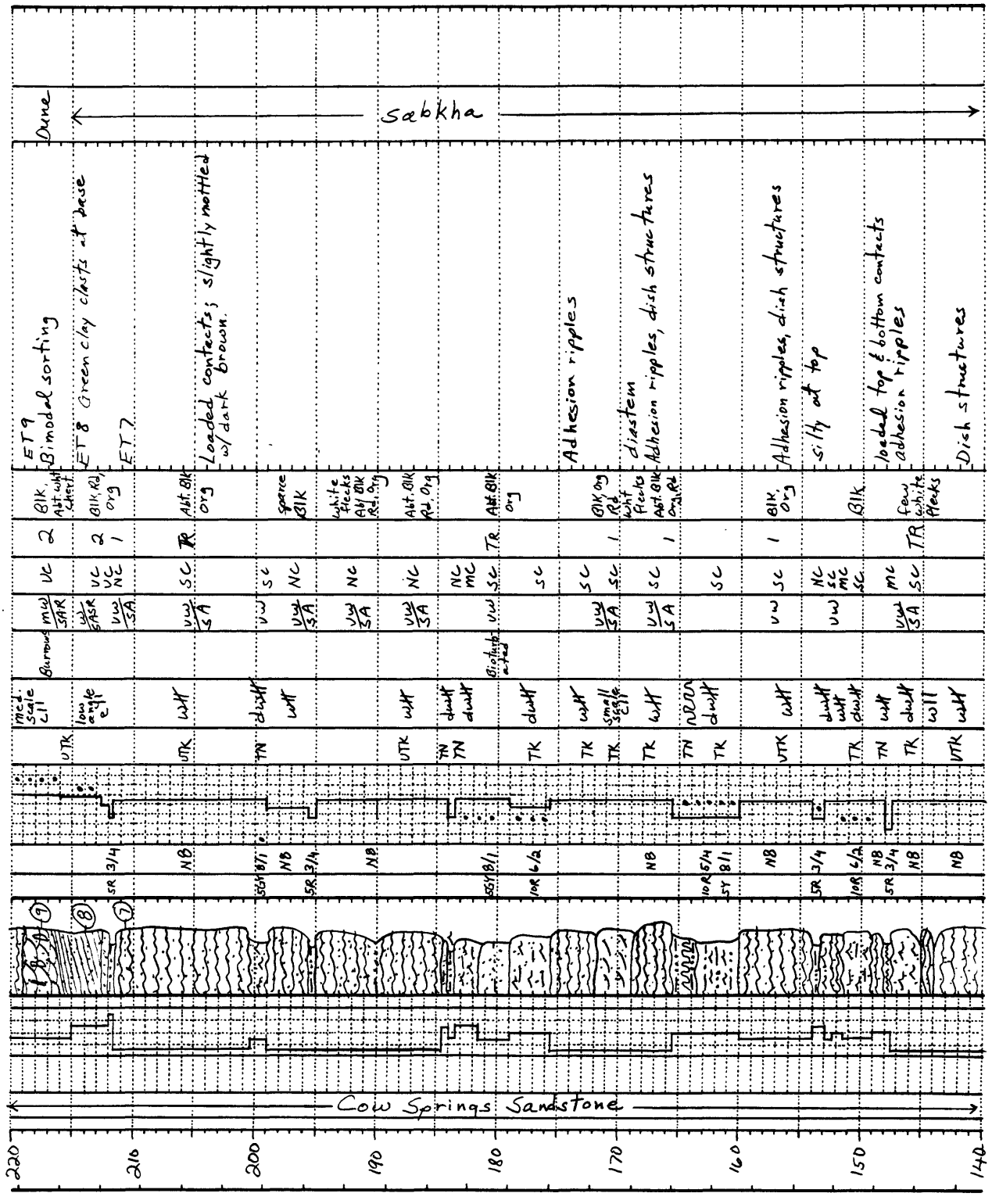
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION East Thoreau Sec. W½ sec. 13 T. 14N. R. 13W.

STATE ..... COUNTY .....

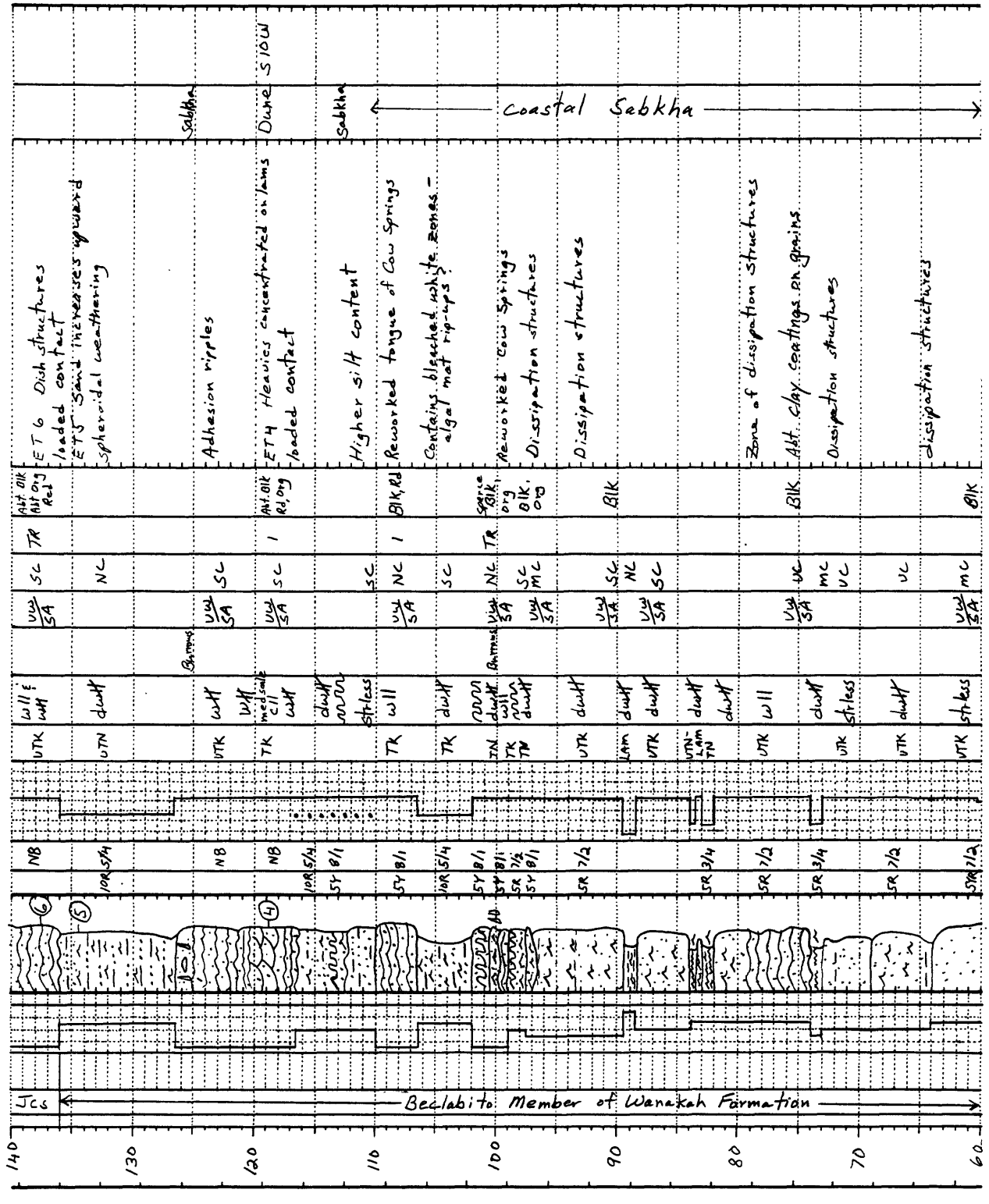
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION East Thoreau Sec. W½ Sec. 13 T. 14N. R. 13 W.

STATE ..... COUNTY .....

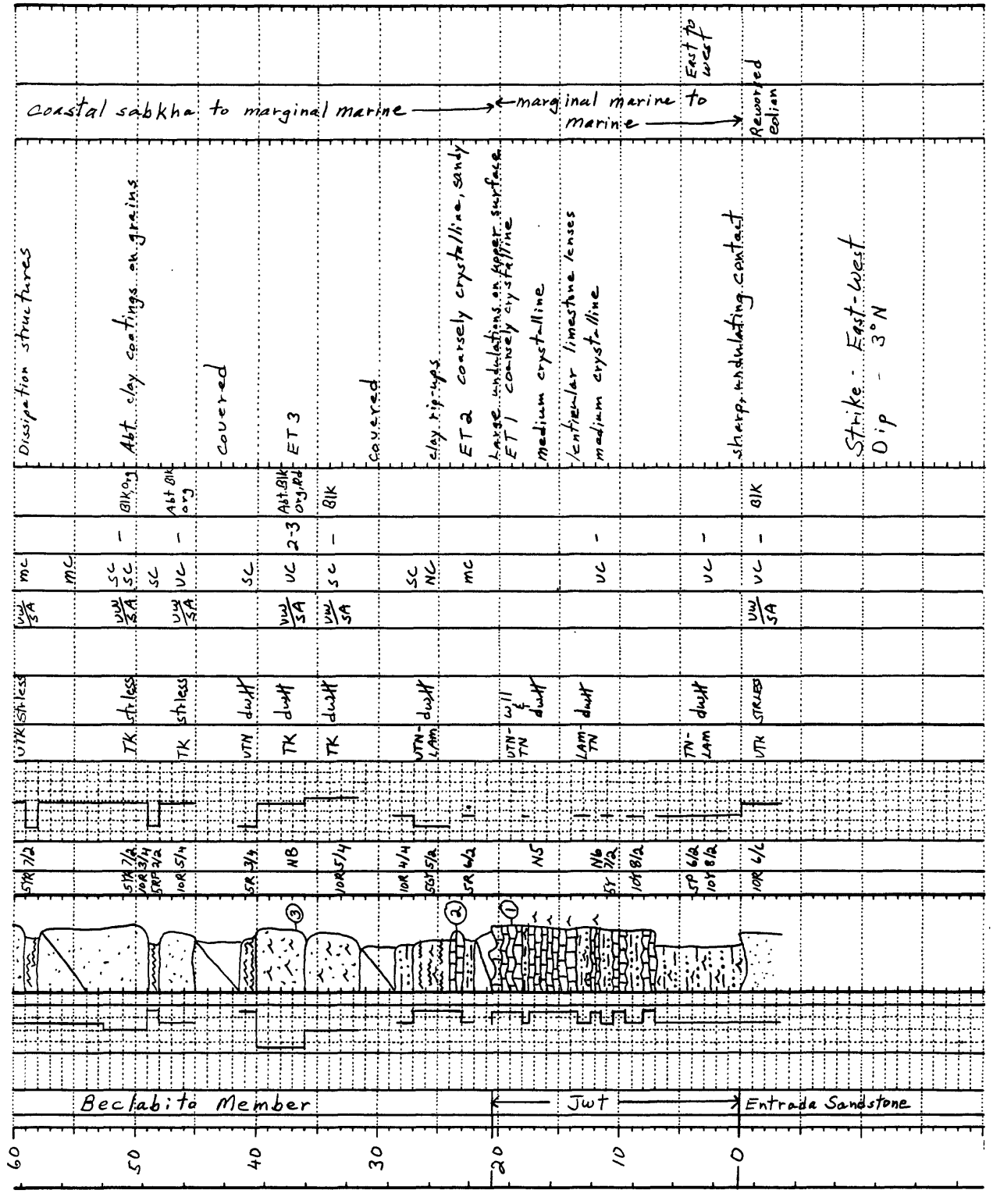
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION East Thoreau Sec. W 1/2 Sec. 13 T. 14 N. R. 13 W.

STATE New Mexico COUNTY McKinley

U.S.G.S. CORE LIBRARY NUMBER API WELL NUMBER



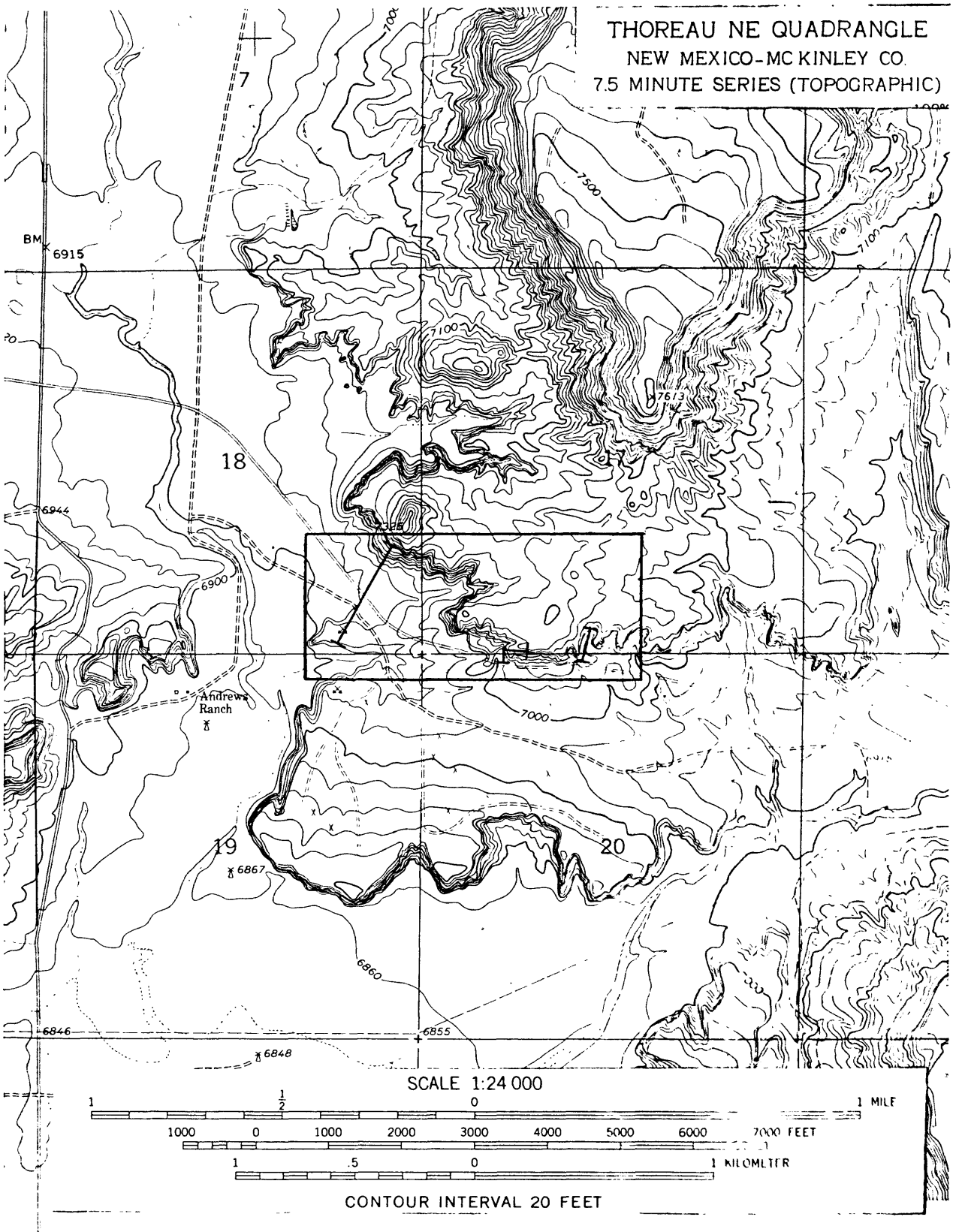


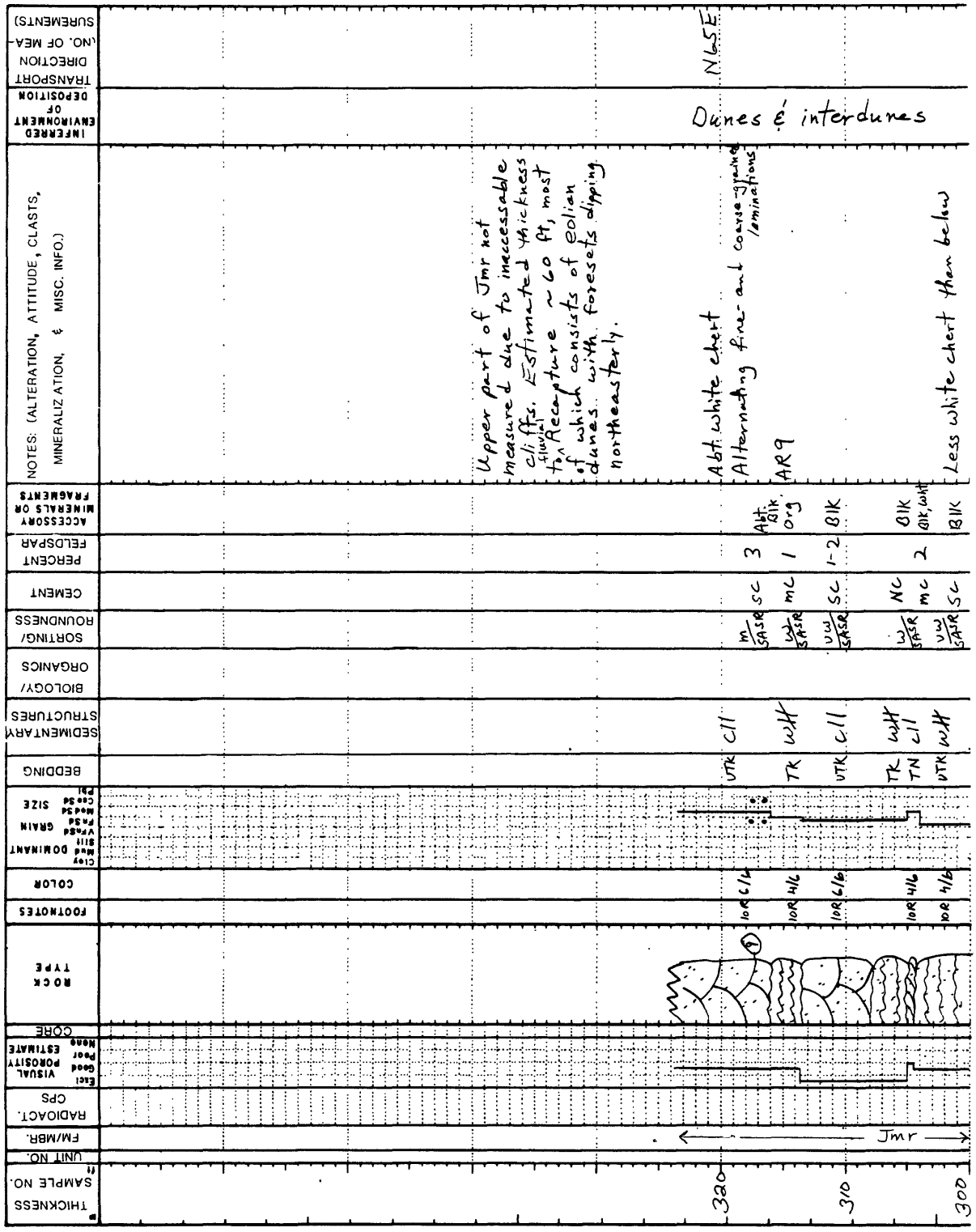
Figure 8. Location of Andrews Ranch section.

5. LOCATION Andrews Ranch SW¼ Sec. 17; SE¼ Sec. 18; N½ Sec. 20 Sec. ... T. 14 N R. 11 W QUADRANGLE (7.5') Thoreau NE

STATE New Mexico COUNTY McKinley DATE 7/23-7/24. 1984

LAT.-LONG. ... GEOL. Condon, Peel

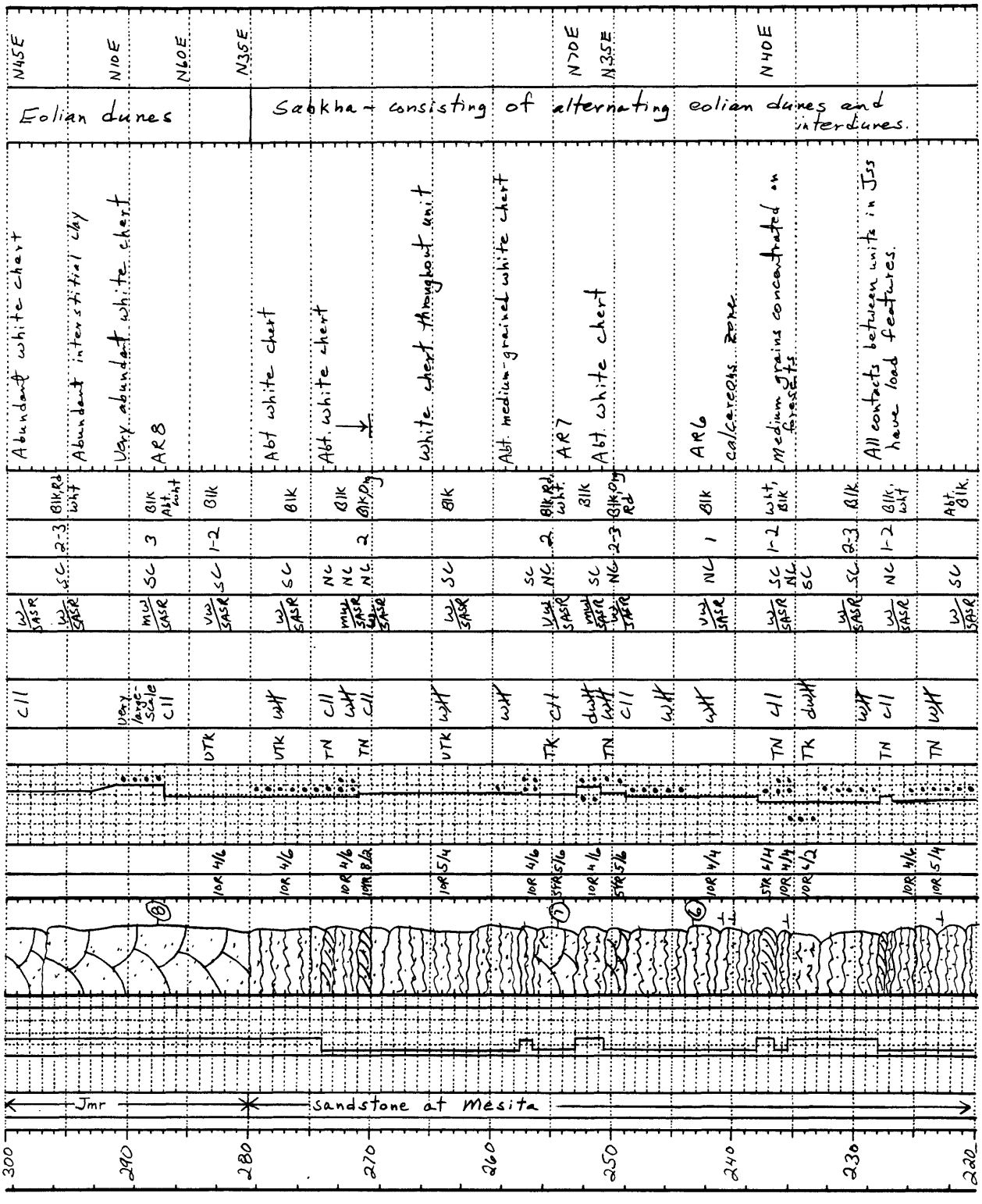
STRATIGRAPHIC SECTION DESCRIPTION (STRAT. INTERVAL Jmr TO Jss)



LOCATION Andrews Ranch Sec. 17, 18, 20 T. 14 N R. 11 W.

STATE COUNTY

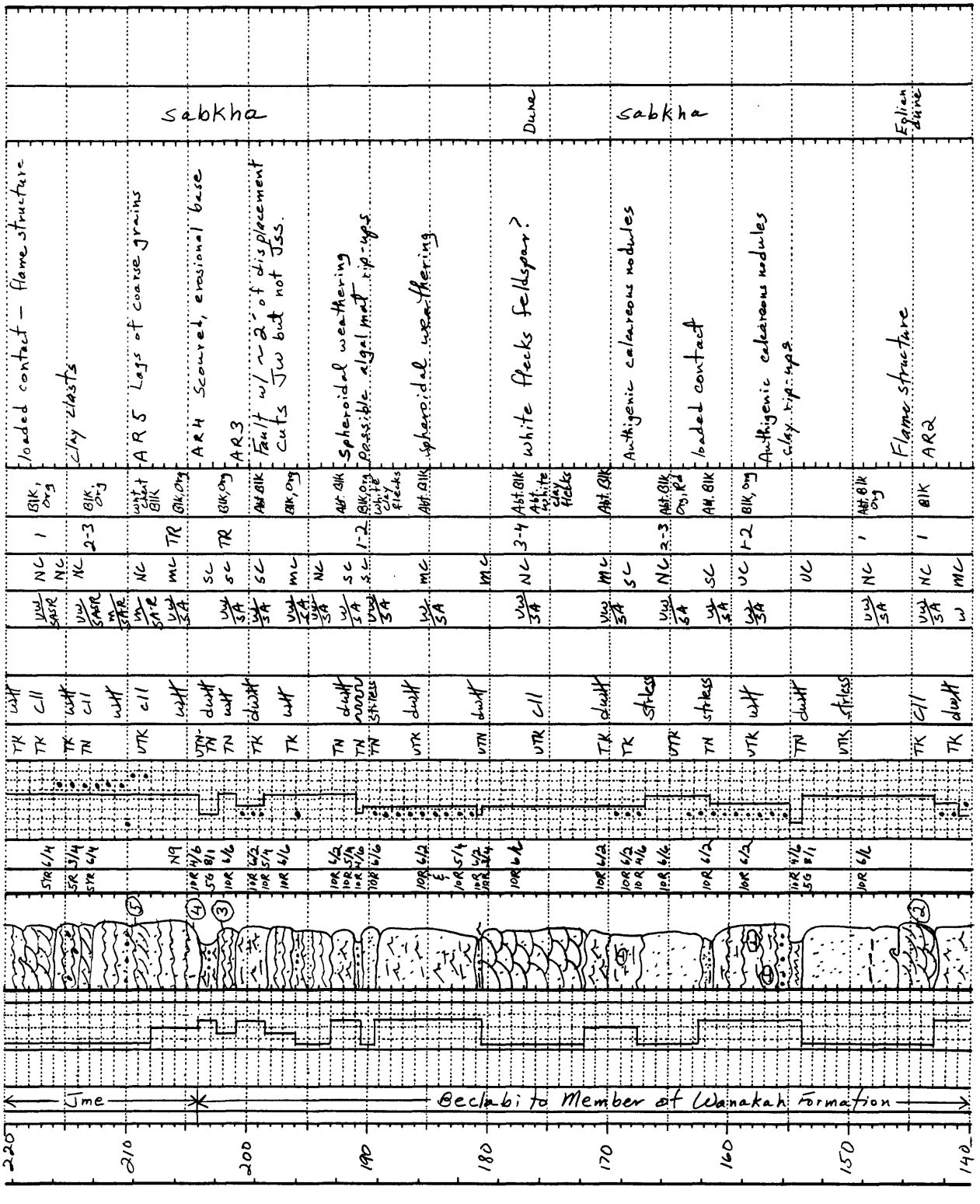
U.S.G.S. CORE LIBRARY NUMBER API WELL NUMBER



LOCATION Andrews Ranch Sec. 17, 18, 20 T. 14 N. R. 11 W

STATE ..... COUNTY .....

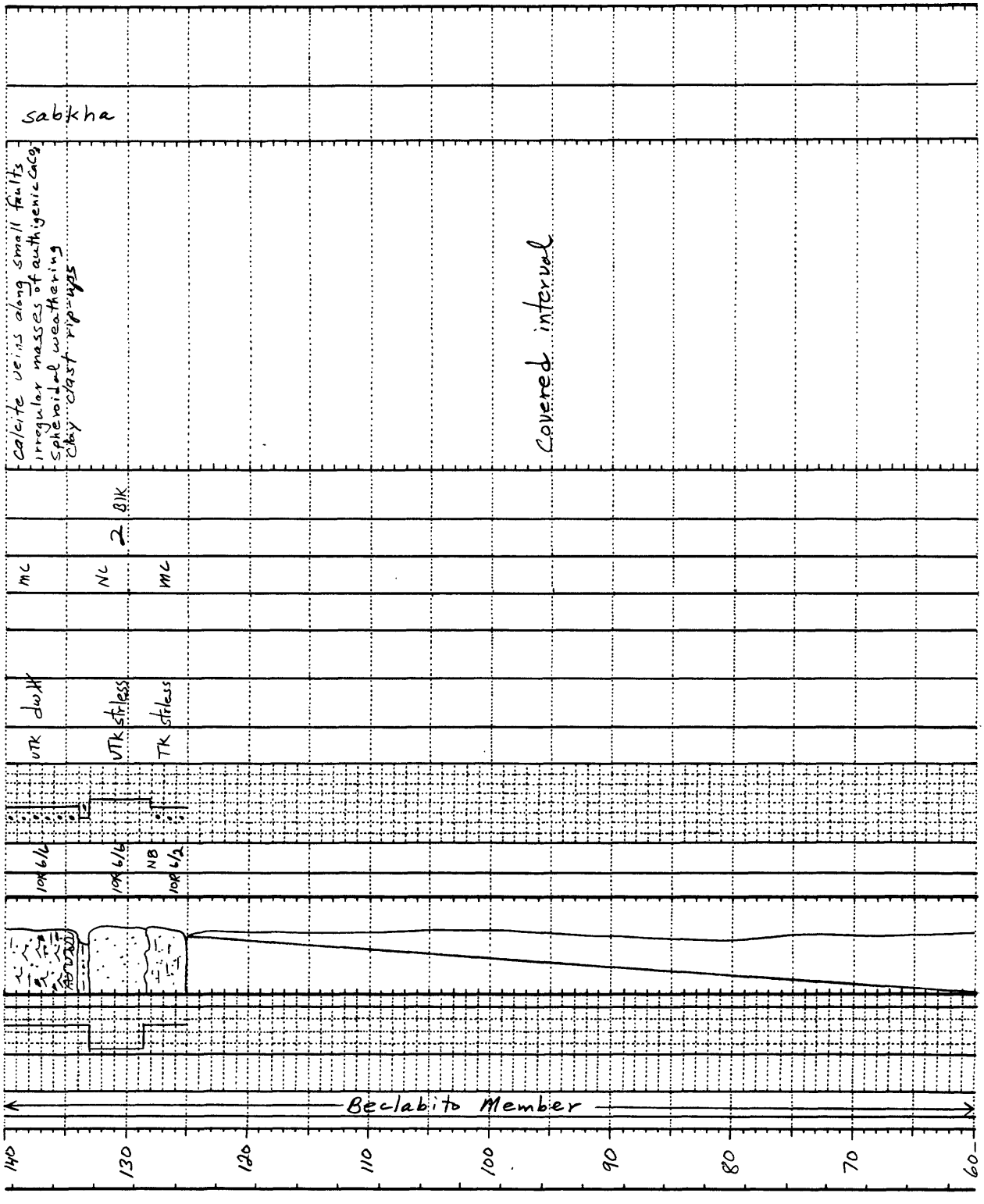
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Andrews Ranch Sec. 17, 18, 20 T. 14N R. 11W

STATE COUNTY

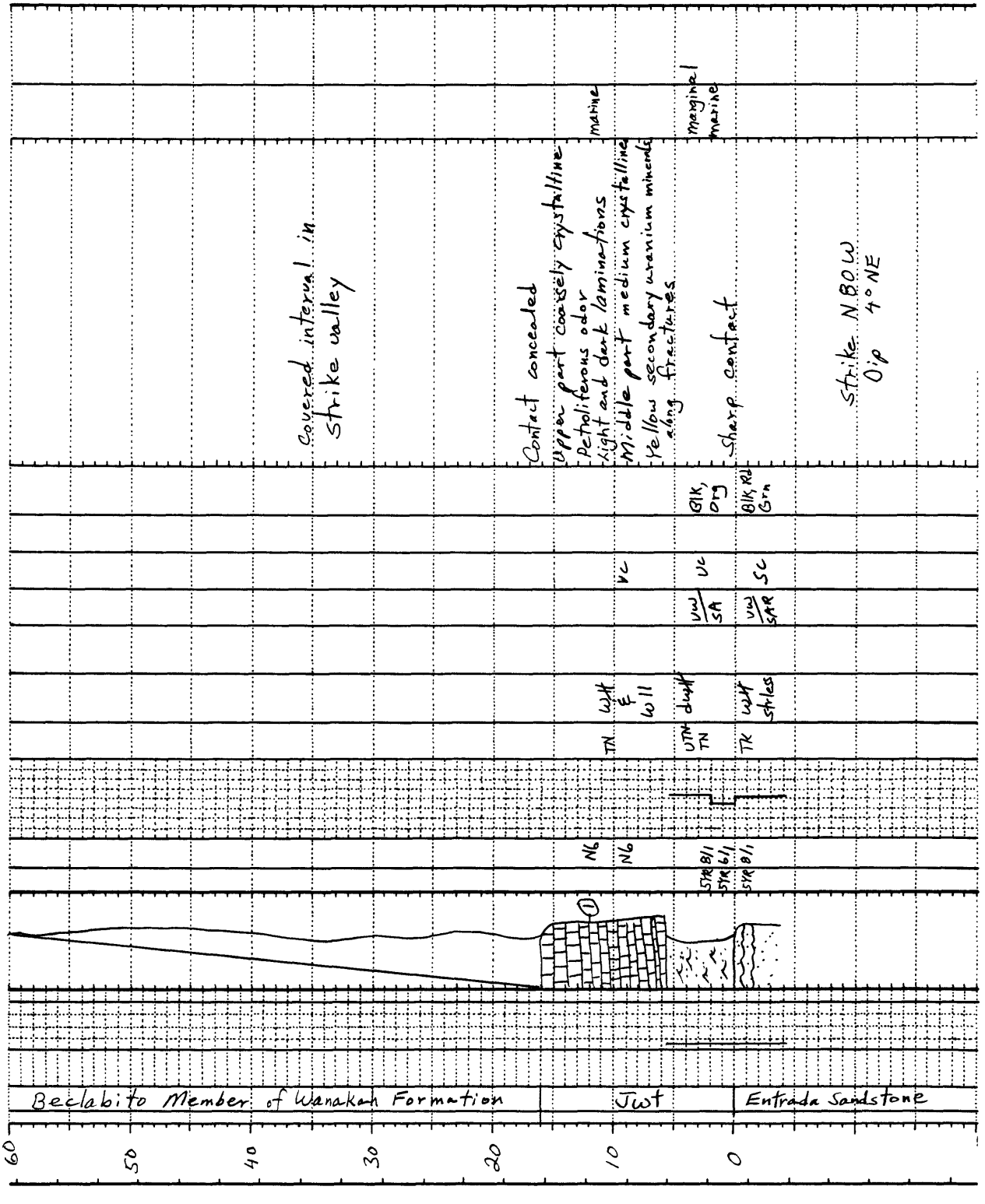
U.S.G.S. CORE LIBRARY NUMBER API WELL NUMBER



LOCATION Andrews Ranch Sec. 17, 18, 20 T. 14 N. R. 11 W.

STATE ..... COUNTY .....

U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



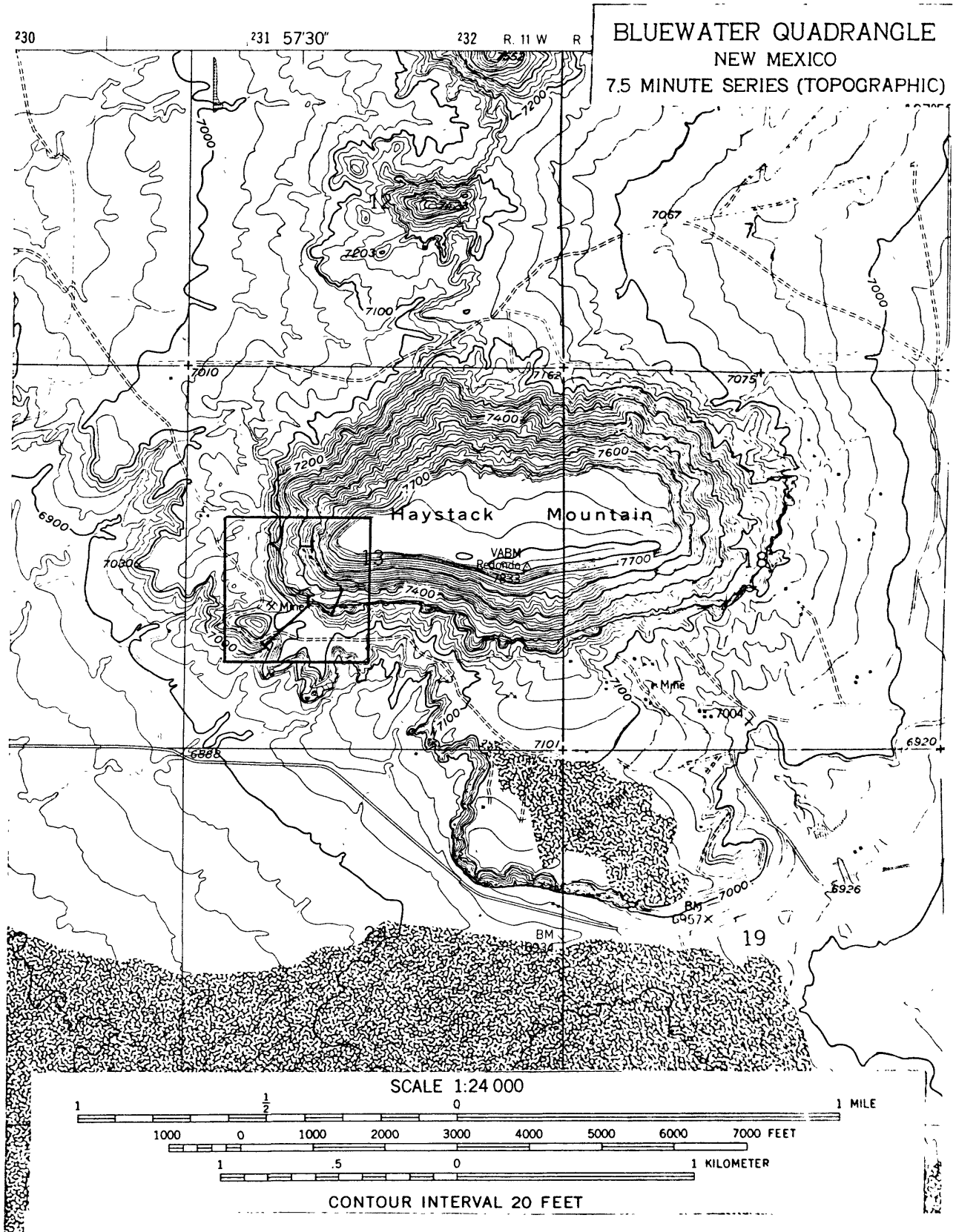
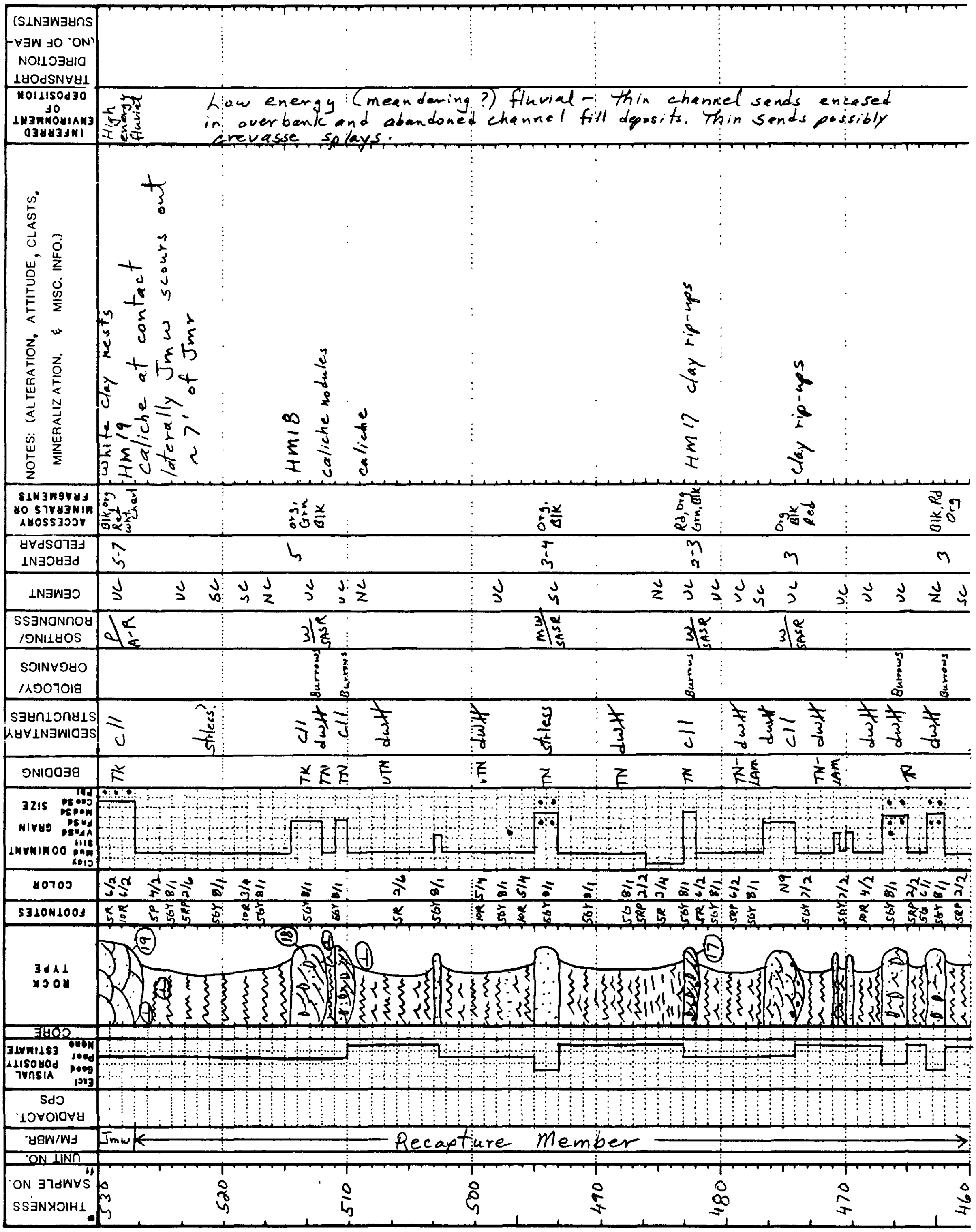


Figure 9. Location of Haystack Mountain section.

6. LOCATION Haystack Mountain Sec. W1/2 13 T. 13N R. 11W QUADRANGLE (7.5') Bluewater
STATE New Mexico COUNTY McKinley DATE 7/25-7/26 1984
LAT.-LONG. GEOL. Condon, Pool

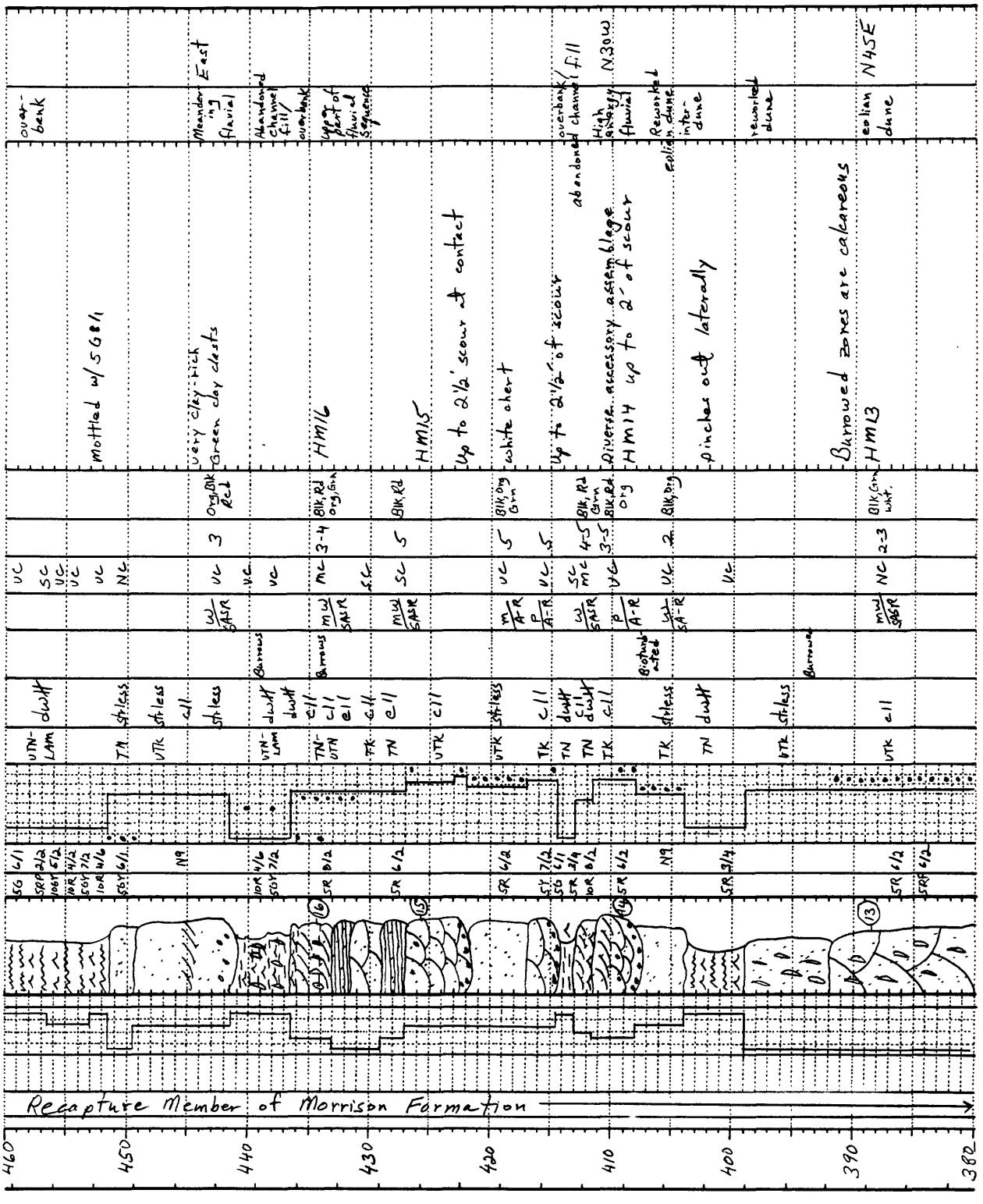
STRATIGRAPHIC SECTION DESCRIPTION (STRAT. INTERVAL Je TO Jmw)



LOCATION Haystack Mountain Sec. W½ Sec. 13 T. 13 N. R. 11 W.

STATE ..... COUNTY .....

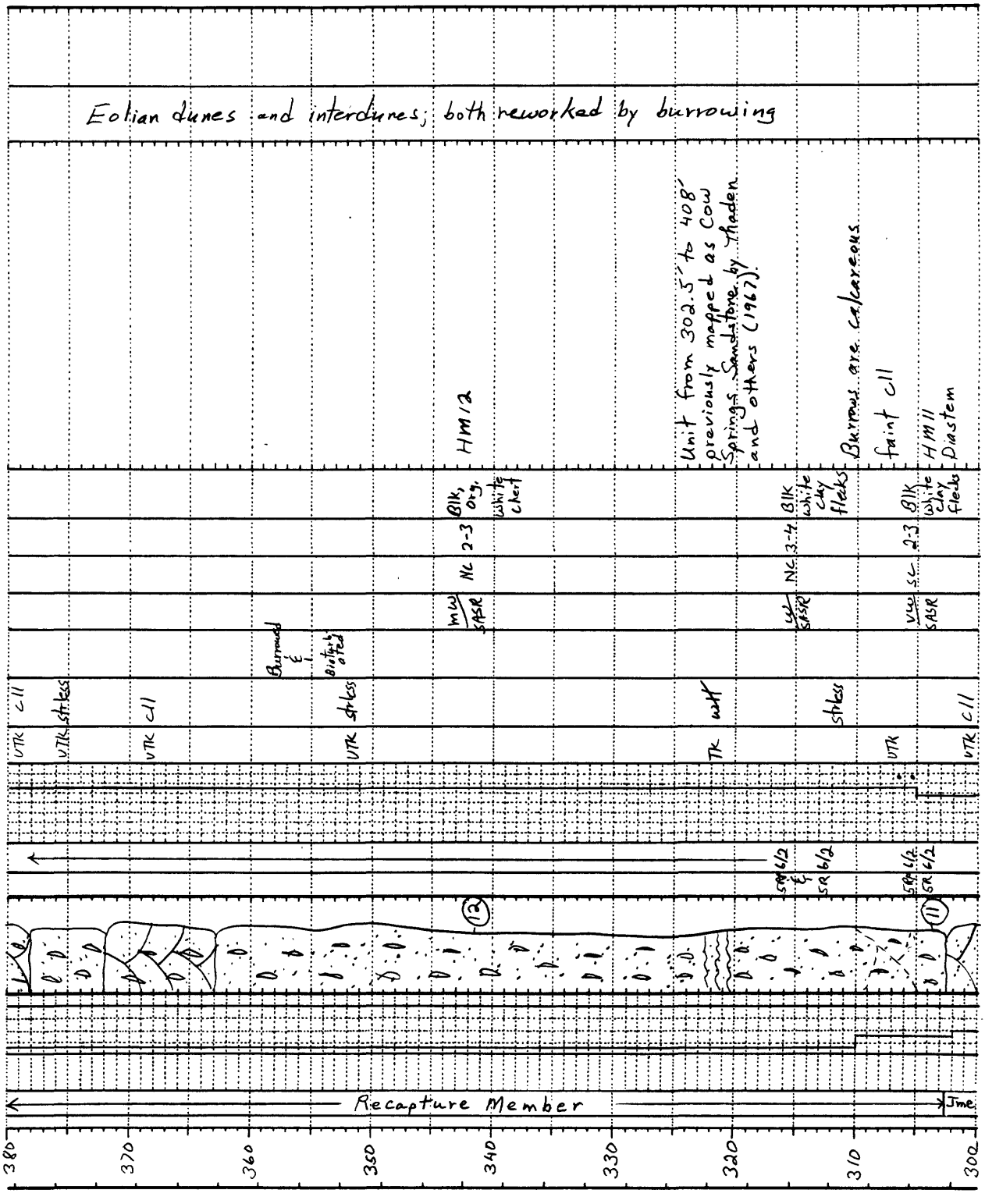
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Haystack Mountain Sec. W½ sec. 13 T. 13N. R. 11W.

STATE ..... COUNTY .....

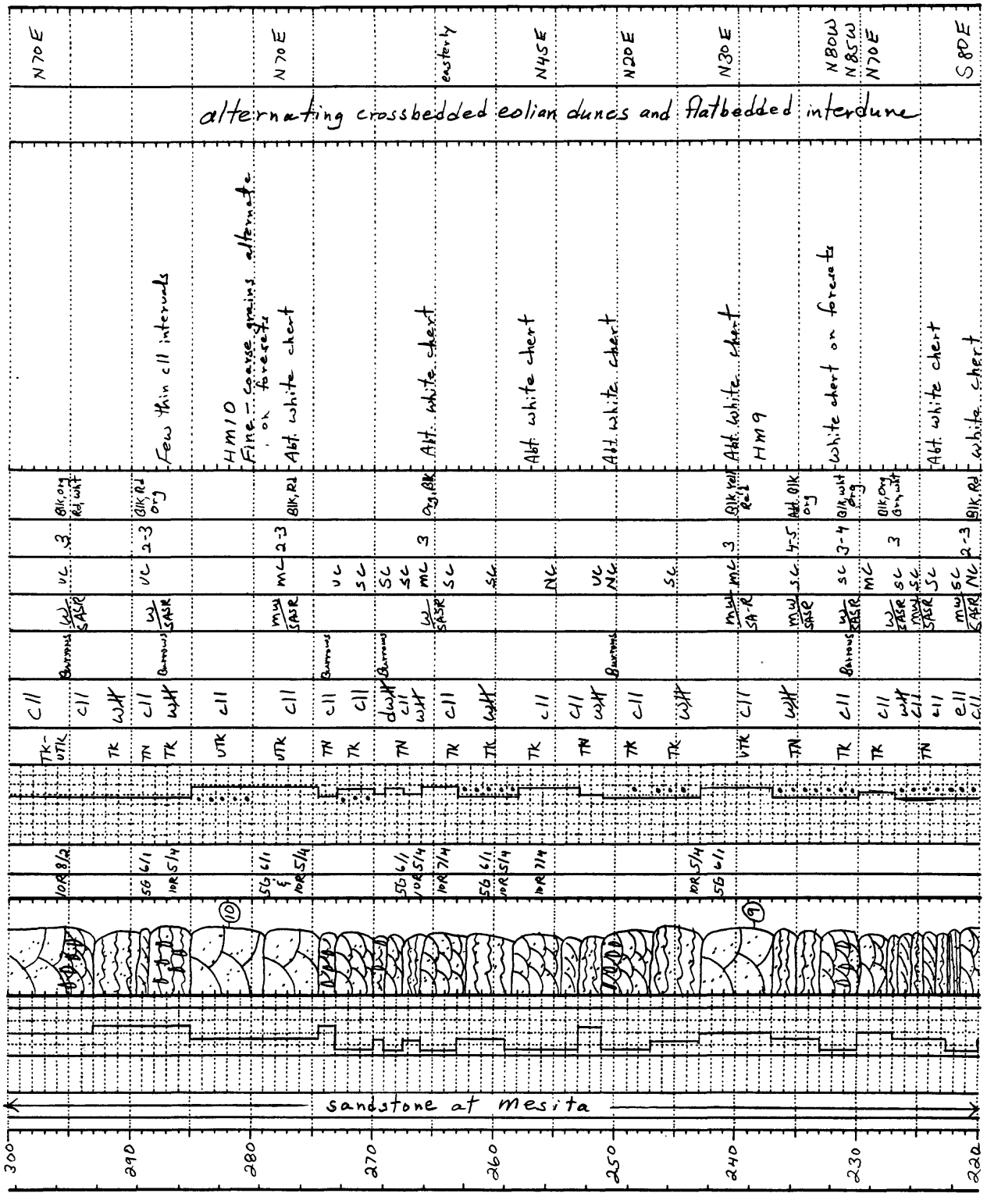
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Haystack Mountain Sec. W 1/2 Sec. 13 T. 13 N. R. 11 W.

STATE ..... COUNTY .....

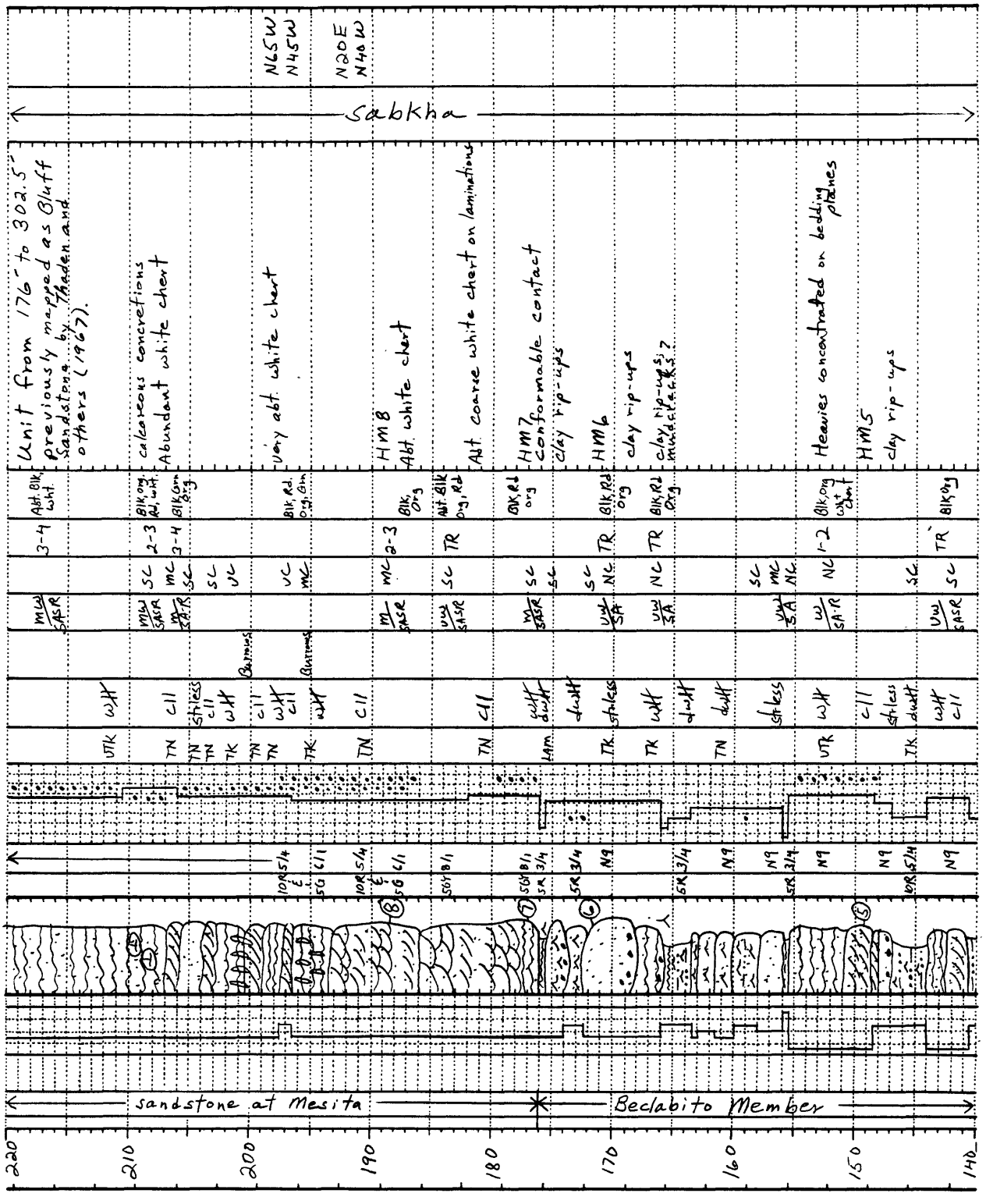
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Haystack Mountain Sec. W½ Sec. 13 T. 13 N. R. 11 W.

STATE ..... COUNTY .....

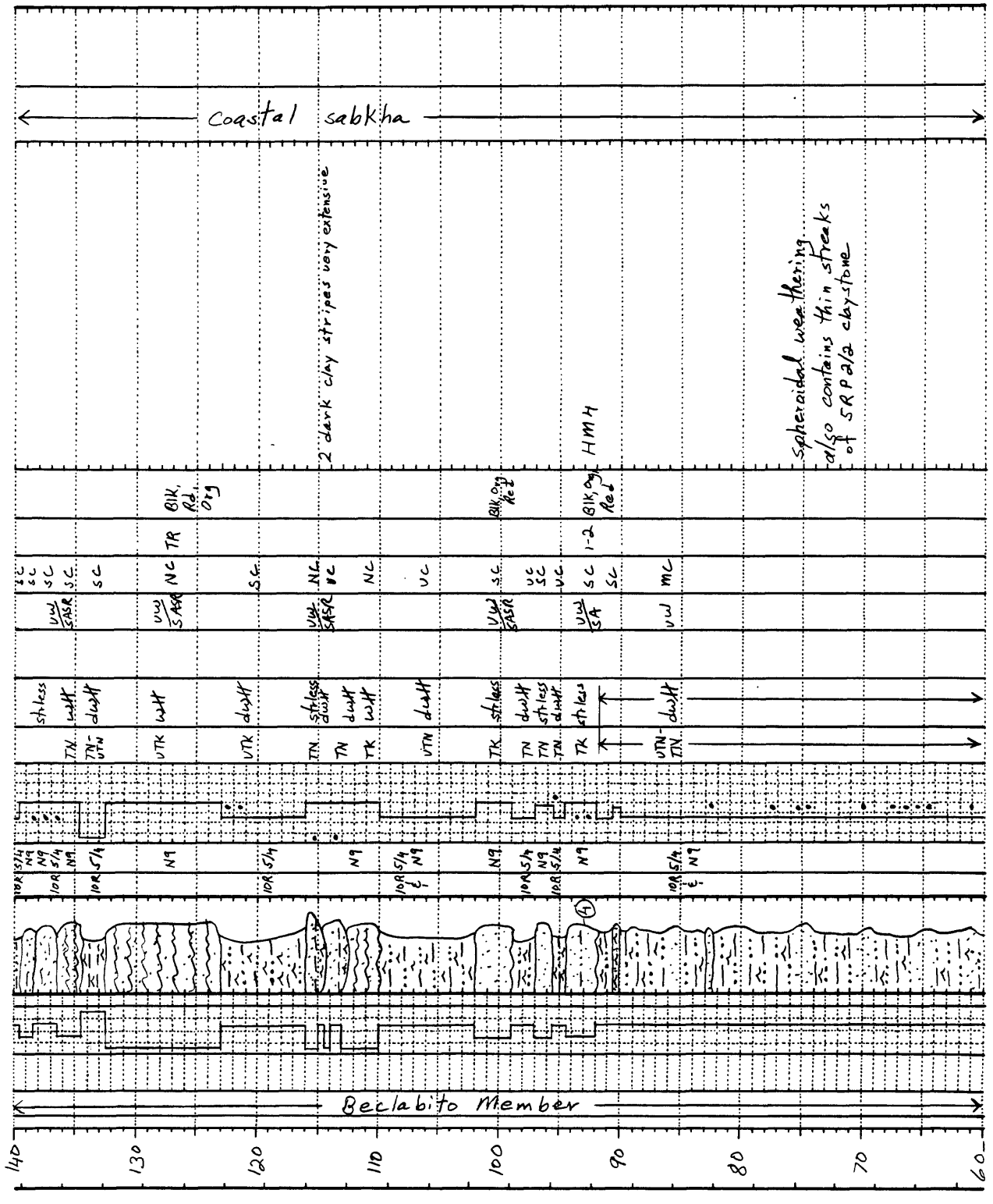
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Haystack Mountain Sec. W½ Sec. 13 T. 13 N. R. 11 W.

STATE ..... COUNTY .....

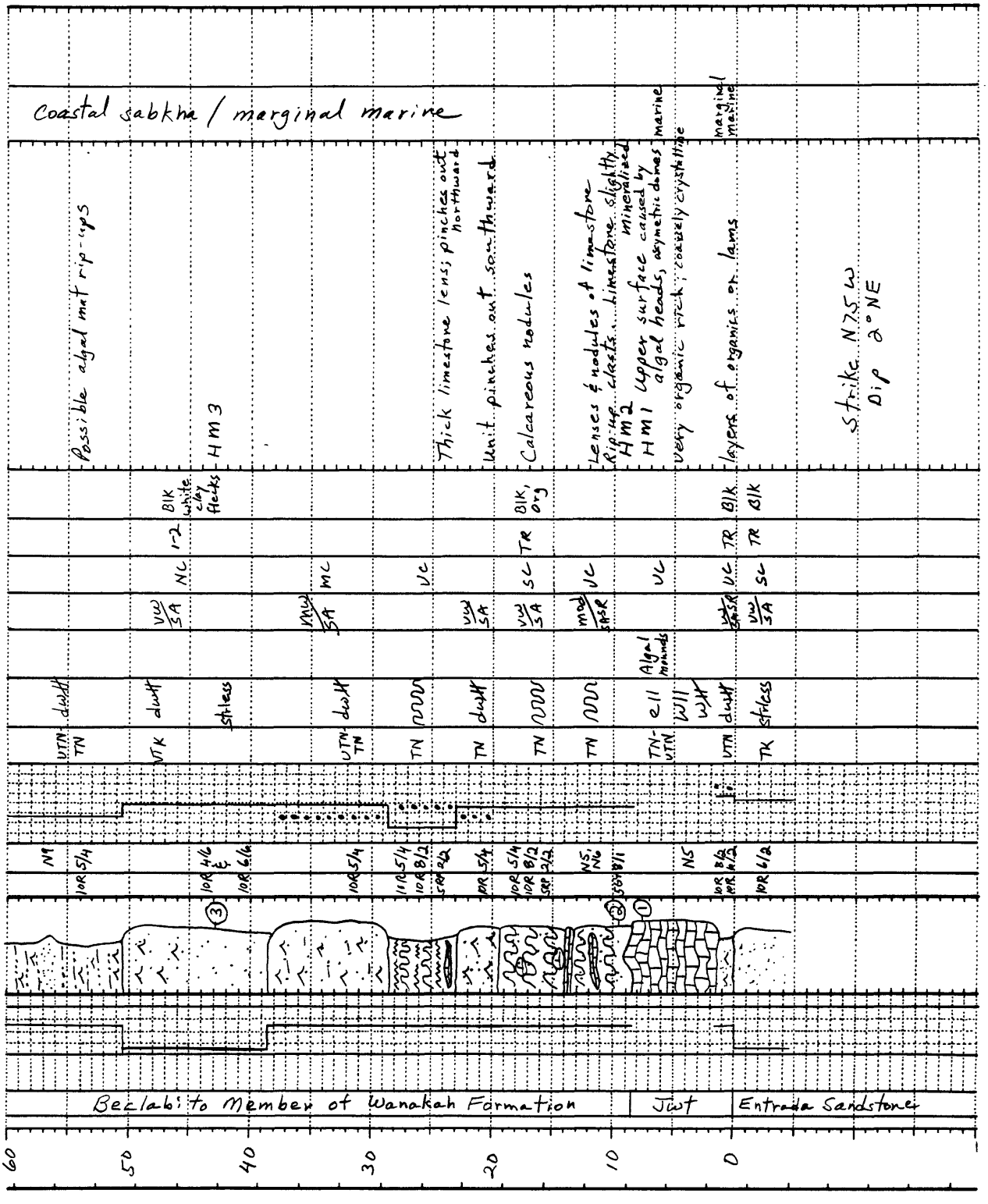
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Haystack Mountain Sec. W½ sec. 13 T. 13 N. R. 11 W.

STATE ..... COUNTY .....

U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



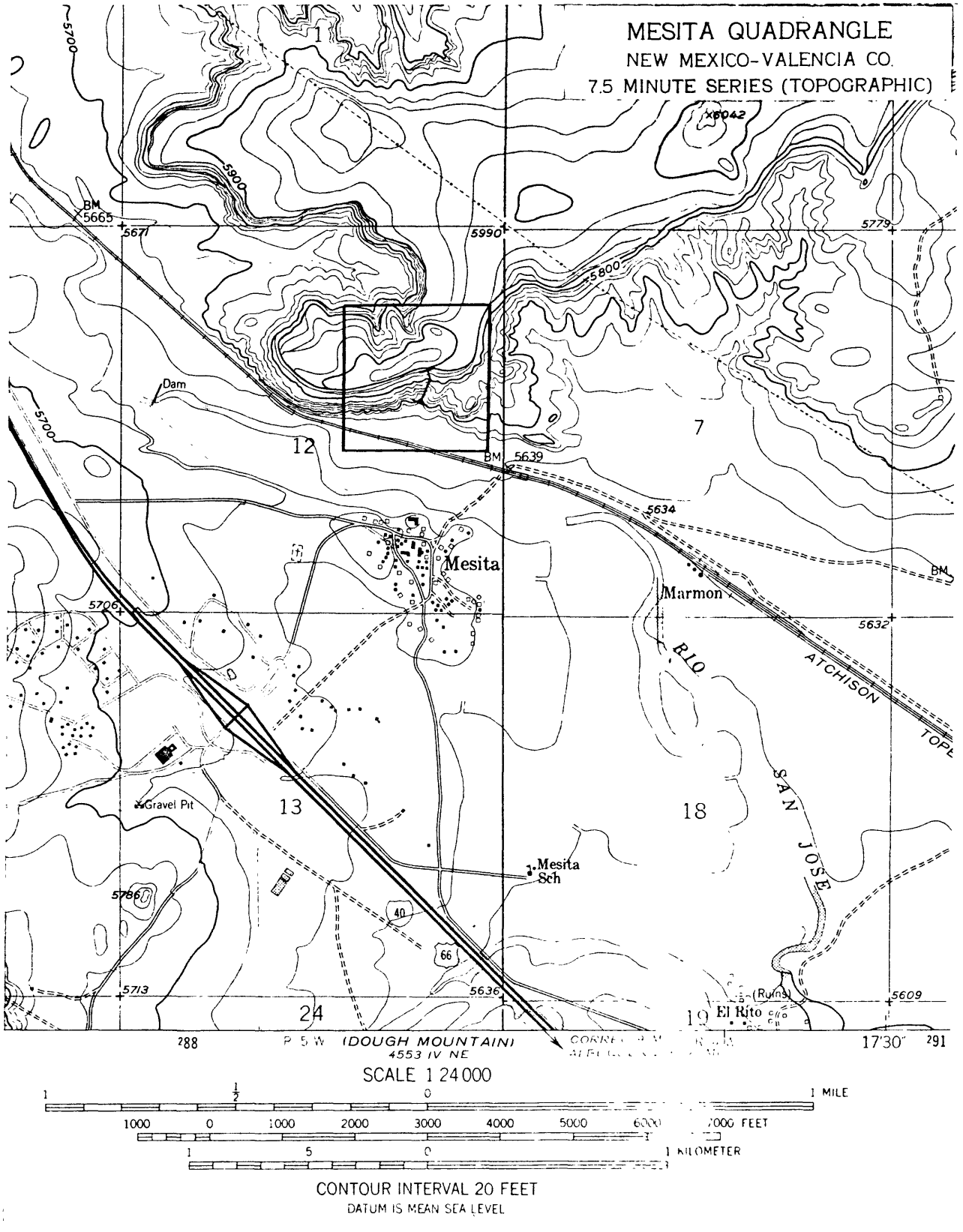
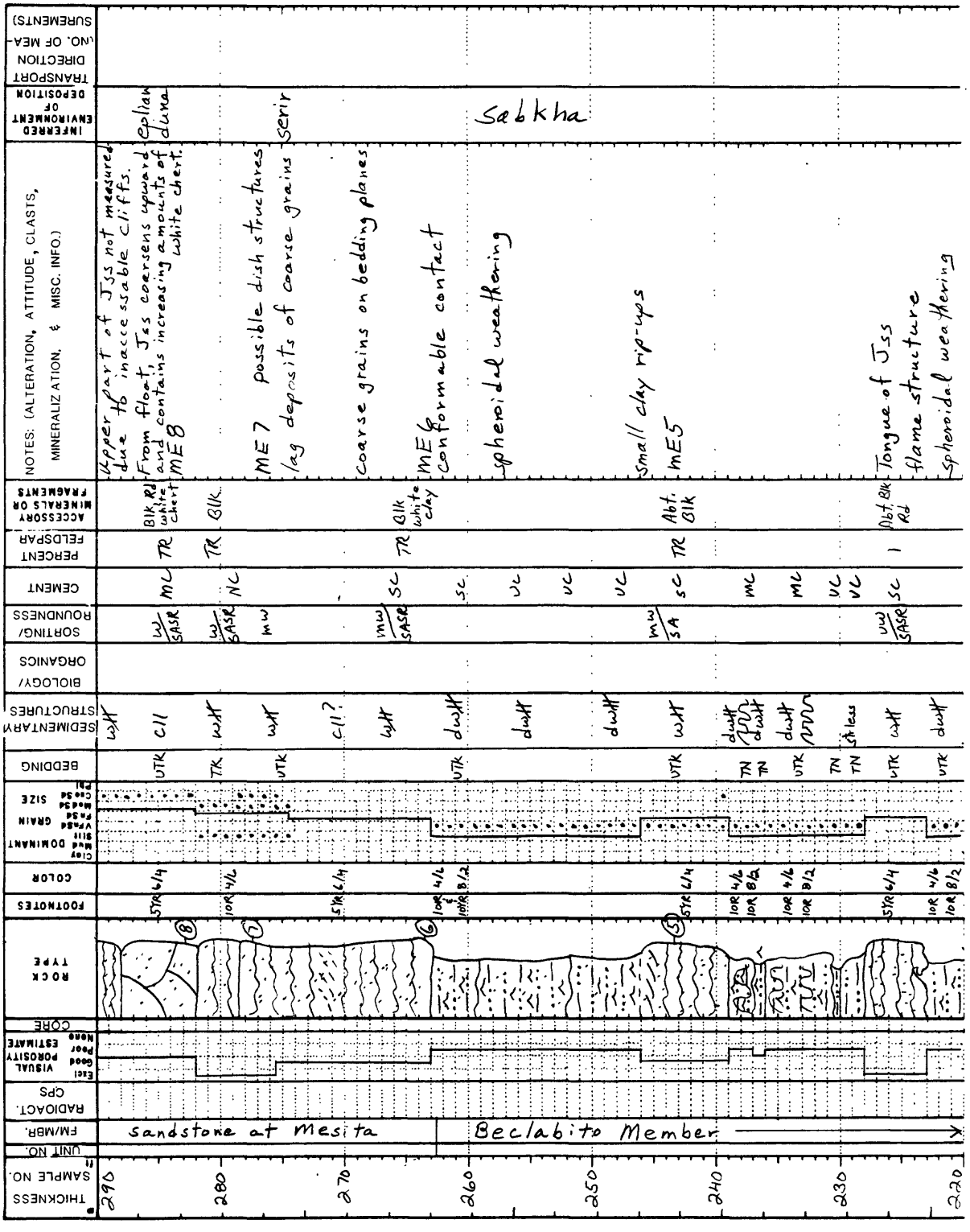


Figure 10. Location of Mesita section.

STRATIGRAPHIC SECTION DESCRIPTION (STRAT. INTERVAL Je.....TO Jss.....)

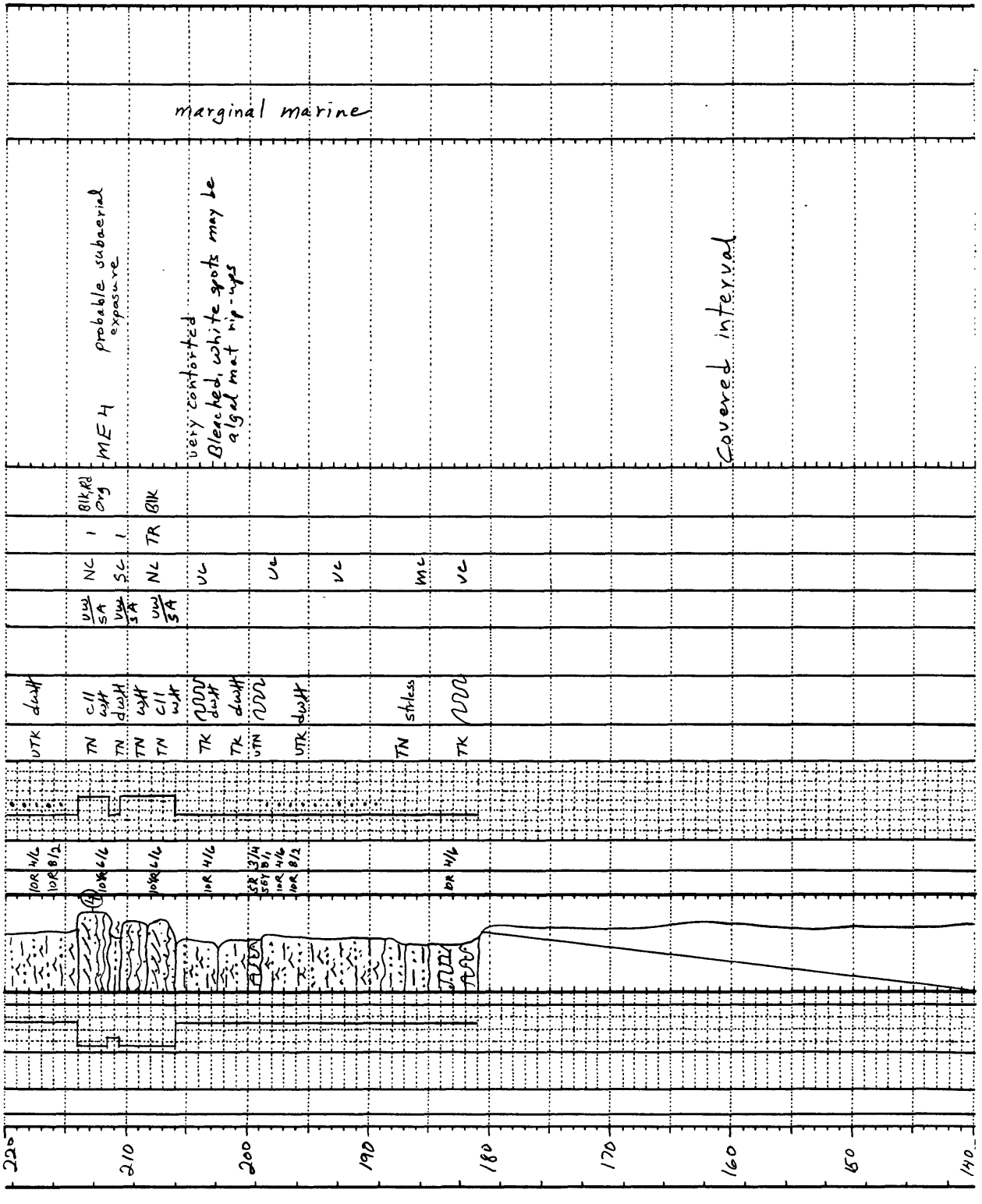
7. LOCATION Mesita SE1/4 NE1/4 Sec. 12 T. 9N R. 5W QUADRANGLE (7.5') Mesita
STATE New Mexico COUNTY Valencia DATE 7/30/1984
LAT.-LONG. GEOL. Condon, Peel



LOCATION Mesita Sec. 12 T. 9N R. 5W.

STATE ..... COUNTY .....

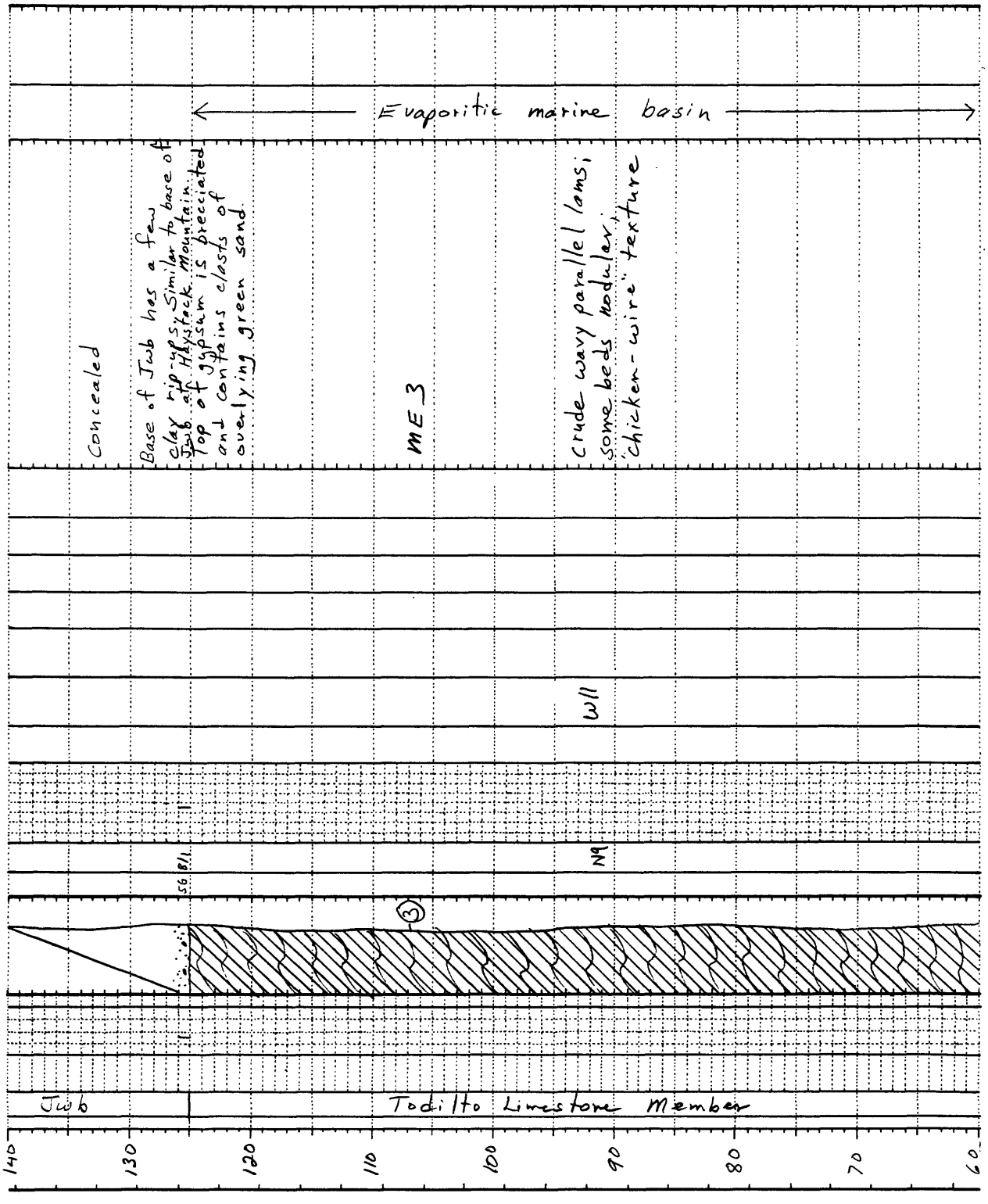
U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....



LOCATION Mesita Sec. 12 T. 9N. R. 5W.

STATE COUNTY

U.S.G.S. CORE LIBRARY NUMBER API WELL NUMBER



LOCATION Mesita Sec. SE¼ NE¼ 12 T. 9N. R. 5W.

STATE ..... COUNTY .....

U.S.G.S. CORE LIBRARY NUMBER ..... API WELL NUMBER .....