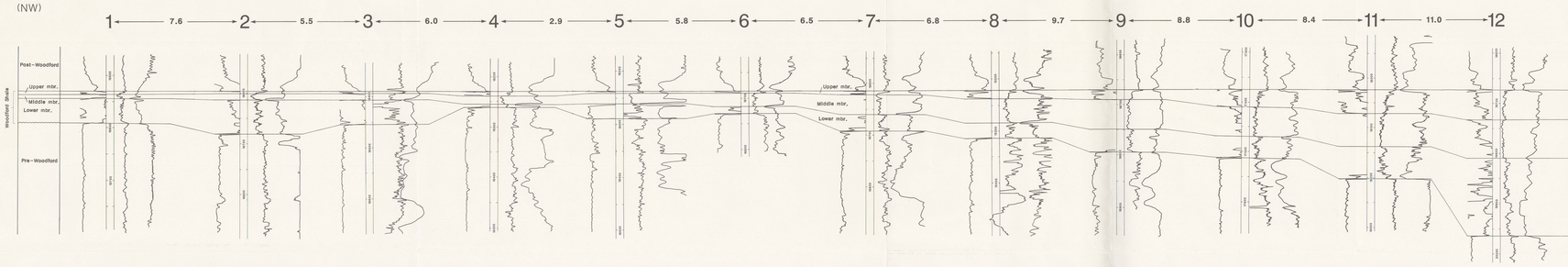

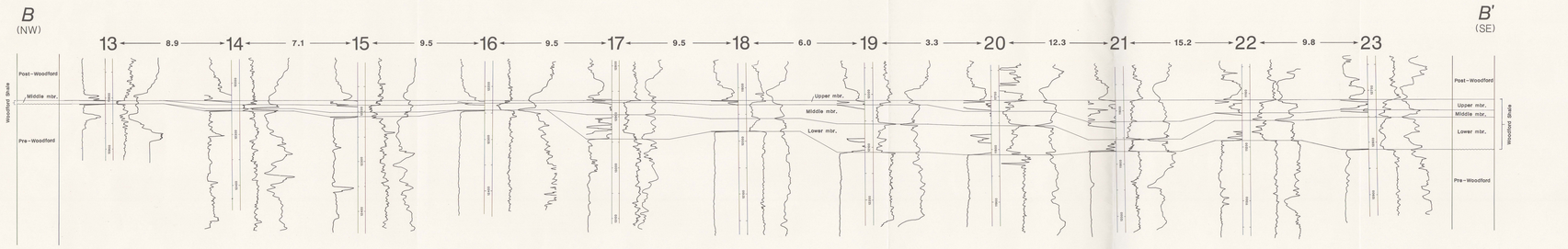

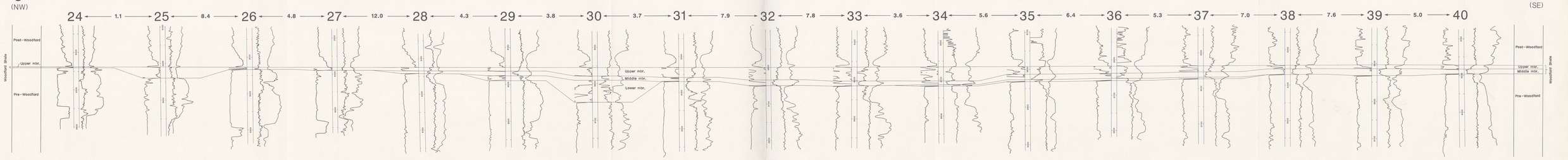

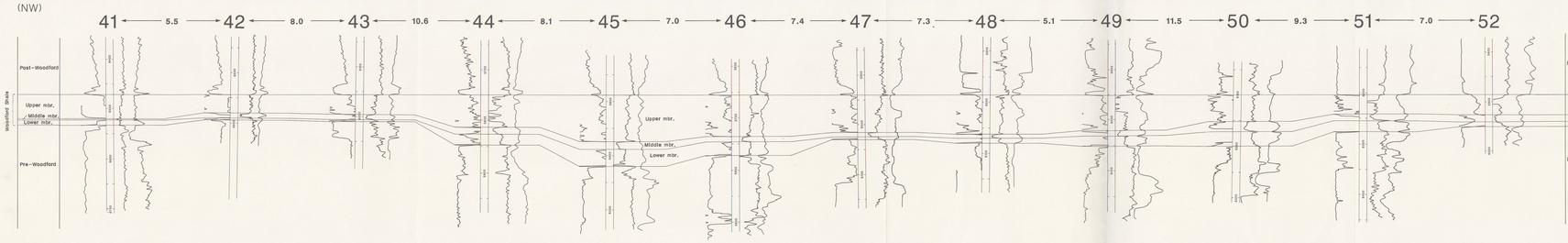

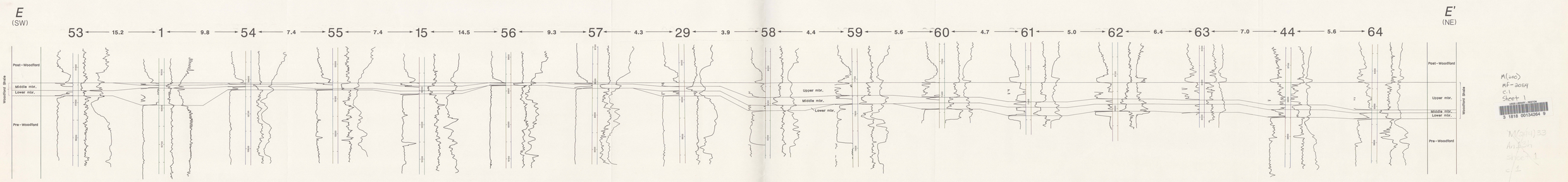

INTRODUCTION

The Woodford Shale is one of several black, organic-rich shales of Late Devonian to Early Mississippian age that are present in basins of the North American craton. Black shales of similar age include the Antrim Shale of the Michigan basin, the New Albany Shale of the Illinois basin, the Bakken Formation of the Williston basin, the Exshaw Formation of the Alberta basin, and the several "Devonian" shales of the Appalachian basin. Black shales of Late Devonian age also have significant economic importance as hydrocarbon source rocks.

The Woodford Shale is a highly radioactive, carbonaceous and siliceous, dark-gray to black shale widely regarded as an important hydrocarbon source rock in the Anadarko basin, Oklahoma (Cardott and Lambert, 1985). Its thickness ranges from near zero to about 100 ft (30 m) on the extensive shelf areas, and increases to more than 900 ft (270 m) in the deep basin in the southwestern part of the study area. Average thickness in the area of this study (fig. 1) is about 300 ft (90 m).

Although vertical variations in lithology, paleoecology, and organic chemistry have been observed locally (Adkison, 1960; Urban, 1960) and regionally (Sullivan, 1985) in the Woodford Shale, no conclusive regional synthesis of such variations has been previously published. In this study, the Woodford Shale is subdivided into three informal stratigraphic units—the upper, middle, and lower members. These three units—called herein the upper, middle, and lower members of the Woodford Shale—are defined on cross sections constructed from 99 wells distributed throughout the northern and central part of the Anadarko basin (fig. 1). Log signatures characteristic of each member are described and preliminary observations of regional depositional patterns are noted. Subdivision of the Woodford Shale into three informal members provides a framework for detailed studies of depositional patterns and source-rock properties of this formation.

DEFINING UPPER, MIDDLE, AND LOWER MEMBERS OF THE WOODFORD SHALE

Distinctive variations in the signatures of gamma-ray, formation-density, and resistivity logs can be recognized in the Woodford Shale. These log variations represent changes in physical properties of the shale and are the basis used here for subdividing the Woodford. Such log-property changes may not correlate with lithostratigraphic units, but three major subdivisions can be correlated throughout the study area.

Criteria for defining the upper, middle, and lower members of the Woodford Shale are illustrated by the type logs (fig. 2), which show all of the log characteristics used to define the three members in the study area. Because the log character of the three members varies somewhat laterally, no single well penetration may show all of the log characteristics. However, variations of log character can be traced laterally on the seven cross sections of this report, and these cross sections depict and define the three members of the Woodford.

Log Character of Upper, Middle, and Lower Members

The Woodford Shale may be generally described as two similar shale members separated by a less dense, more radioactive, and usually more resistive middle member (fig. 2). The contacts between the middle member are not gradational but are defined by sharp density-log and gamma-ray-log deflections. In addition, the base of the middle member is marked in many wells by a negative resistivity spike (fig. 2).

Shales and limestones of the overlying post-Woodford (Kinderhookian) rocks are more dense and less radioactive than the upper member of the Woodford Shale. Thus, the top of the upper member is defined by a sharp increase in radioactivity and a decrease in resistivity and a decrease in density (fig. 2); resistivity usually increases downhole across this boundary (fig. 2), but the increase is not always well defined.

In many wells, the lower member of the Woodford Shale is slightly less dense and slightly more radioactive than the upper member. The base of the lower member is marked by an increase in gamma-ray intensity and a decrease in formation density relative to underlying rocks of Devonian or Silurian age. The lower contact commonly is a sharp and recognizable contact (fig. 2). Resistivity usually increases upholes across the base of the Woodford Shale, but the increase may not be well defined.

STRATIGRAPHIC CROSS SECTIONS

The cross-section network, based on the 99 wells listed in table 1, consists of 7 cross sections that are based on the gamma-ray, resistivity, formation-density, and induction-resistivity logs of the Woodford Shale, arranged as shown in figure 2, are displayed for each well. Datum for the cross sections is the top of the Woodford Shale. These cross sections define the upper, middle, and lower members of the Woodford Shale in the study area.

The regional tripartite zonation of the Woodford Shale reveals depositional patterns that were controlled by a basin that was created as a single unit. For example, most cross sections show that the middle member of the Woodford Shale generally onlaps the lower member. The upper member tends to onlap the middle member in the northeastern part of the study area (eastern edge of all cross sections), but offlaps the middle member at the southwestern depositional edge of the formation (cross sections A-A', B-B', C-C', and E-E'). These relationships suggest general transgression during Woodford time coupled with a shift of depocenter to the northeast during deposition of the upper member.

Local variations in thickness of the lower member of the Woodford Shale are controlled by the topography of the underlying Hunton Group relief on the pre-Woodford surface appears to be generally greater in the middle shelf areas than in the northeast part of the study area. A persistent area of thinning or nondeposition of the lower member that trends northwest-southeast across the study area indicates a positive, regional structural feature that separated the lower Woodford member into southwest and northeast depocenters (cross sections B-B', F-F', and G-G'); this structural feature is reflected in the middle and upper members as well.

Because the lower member tended to bury and obliterate local pre-Woodford topography, the thickness of the middle member of the Woodford Shale varies more uniformly than that of the lower member. Regional thinning and thickening of the middle member correlates to some extent with that of the lower member, probably as a result of continued activation of basement features, and to a lesser extent, of differential compaction of the lower members.

The middle member of the Woodford Shale, like the lower member, tends to thicken to the southeast towards the central trough of the southern Oklahoma aulacogen. The upper member, however, thickens to the northeast toward Kansas. This fundamental change in depositional pattern during upper Woodford time probably reflects initial development of the Sedgwick basin of south-central Kansas (Kelly and Merriam, 1964), coupled with marked slowing of subsidence along the axis of the southern Oklahoma aulacogen.

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EXPLANATION

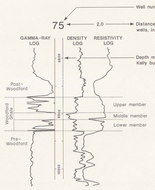

Table 1.--List of wells used to construct cross sections, Anadarko basin, Oklahoma

[Location, operator, and well name are as shown on well-log headers]

Well	Location sec-Tps-Rgs	Operator	Well Name
1	16-18N-24W	Hicks Exploration	16-A Cross
2	24-17N-24W	Lone Star Prod	1-24 Berryman
3	23-17N-23W	Energy Reserves Group	1 Eastham
4	23-17N-22W	Shell Oil	1-23 Kennon
5	29-17N-21W	Arkla Exploration	1-29 Harrell
6	19-16N-20W	Hoover & Bracken	1-19 Hallett
7	19-16N-19W	Getty Oil	1-19 Hall
8	6-15N-18W	J C Barnes Oil	1 Cecil Rounds
9	29-14N-18W	C F Braun	1-29 Walker
10	35-14N-17W	J M Huber Corp	1 Arapaho
11	35-13N-16W	Roden Oil	35-1 Henry E Nickel
12	14-11N-15W	Reinerich & Payne	1 Brown Foundation
13	18-10N-14W	Kennedy & Mitchell	38-447 Latta
14	18-21N-22W	Miami Oil Producers Inc	1 Driskell
15	20-21N-21W	Cimarron Engineering	1 Bryant
16	21-20N-20W	Superior Oil	1 Bruce Unit
17	22-19N-19W	Arco Oil & Gas	1 Emmett Buck
18	20-19N-17W	OPT Exploration Inc	1-20 Irene Burgess
19	13-18N-17W	Reinerich & Payne	1-13 Talega Townsite
20	19-17N-16W	Texas Oil & Gas	1 Dietrich 'B'
21	19-17N-14W	Arkla Exploration	1-19 Marshall
22	10-16N-12W	Texaco Inc	1 Bryant
23	34-15N-12W	Cogniza Oil	1 Behan
24	8-25N-21W	Cobra Oil & Gas	1 Kinney 'B'
25	9-25N-21W	A R Dillard Inc	1 W R Kinney
26	1-25N-20W	Woods Petroleum	1 Schaefer
27	28-25N-19W	Mesa Petroleum	1-28 Jansen
28	16-24N-18W	Gulf Oil	2-36 Gulf-State
29	36-24N-17W	Mesa Petroleum	1 Ann Lee
30	25-23N-17W	Sunmark Exploration	1 G & A Whitlaw
31	4-22N-16W	Atlantic Richfield	2 Cora G Case Unit S P
32	27-22N-15W	Rich Vinc Pipeline	1 Dyche
33	11-21N-14W	Tenneco Oil	1-11 Edwards
34	30-21N-13W	Hunt Oil	1 Voth
35	1-20N-13W	Anchorage Oil & Gas	1-1 Kay
36	19-20N-12W	Mobil Producing	1-19 Davis
37	35-20N-11W	Mineral Resources	1-A Reames
38	12-19N-10W	Energy Exchange	1 Leisher
39	11-18N-9W	Energy Reserves Group	1 Garber
40	10-18N-8W	An-Son Corp	1-10 Heller
41	8-27N-17W	Shenandoah Oil	1 Dugan
42	19-27N-16W	Cleary Petroleum Inc	1 Davidson
43	10-27N-14W	Ladd Petroleum	1 Ferrell
44	17-27N-13W	Texaco Inc	1 Stuckey
45	22-27N-12W	Harper Oil	1 Bouziden
46	14-27N-11W	Michigan Oil	1 Hodgson
47	20-26N-10W	Mack Oil	1 Sayer
48	21-26N-9W	Anadarko Production	1-21 Tucker 'E'
49	29-26N-8W	Champlin Petroleum	1 Maxine Garrison
50	7-25N-6W	TXO Production	1 Hardiman 'A'
51	4-24N-5W	Bogert Oil	1 Duffy
52	21-25N-4W	Verrall Engineering	1 Mary Balser
53	4-16N-26W	Hoover & Bracken INC	1-4 Cecil
54	4-19N-23W	Hicks Exploration	4-A Eddie Max
55	6-20N-22W	Anadarko Land & Expl	1-6 Hamilton
56	27-22N-19W	Voods Petroleum	1 Peach
57	26-23N-18W	Apache Corp	1 Garvin Unit
58	19-24N-16W	Texaco Inc	1-19 Hudson
59	35-24N-14W	Clifford Resources	1-35 Bowen
60	1-24N-16W	Natol-Kirkpatrick Oil	1 Tissom
61	26-25N-15W	Amerada Petroleum	1 Beard Estate
62	6-25N-14W	Calvert Fonds Inc	1 Wenzel
63	19-26N-13W	Search Drilling	1-19 Kinne
64	23-28N-13W	Damson Oil	1 Lee
65	4-27N-13W	Mid-Continent	1 Mc Crook
66	9-13N-23W	El Paso Natural Gas	1 Pierce
67	27-14N-24W	Tenneco Oil	1-27 W C Bradshaw
68	27-14N-23W	El Paso Natural Gas	1 Maddox
69	8-15N-22W	Clark-Canadian et al	1 Vierson
70	17-16N-21W	Arkla Exploration et al	1-17 Harrell
71	1-17N-19W	Exxon Corp	1 Sabine
72	17-17N-18W	Texaco Inc	1-17 Hall
73	17-20N-16W	Southland Royalty	1-17 England
74	16-20N-16W	Reading & Bates et al	1 Louthan
75	1-20N-16W	Texas Oil & Gas	1-B Jellison
76	5-20N-15W	Pioneer Production	1-5 Ramsey
77	1-20N-15W	Southport Exploration	1 Mungold
78	3-21N-13W	Viersen & Cochran	1-3 Penner
79	1-21N-12W	Unit	1 Hiebert
80	1-23N-12W	Vaughn Good	2 Sizagren
81	27-24N-11W	Vaughn Good	1 Dugan A
82	19-24N-10W	Rachalb Production	1 Thomas
83	33-25N-10W	California Time Petroleum	1 Ray Hartman
84	12-25N-11W	Anadarko Production	2-12 Noells A
85	21-26N-11W	J M Huber Corp	1 Cherokee Methodist Church
86	27-27N-12W	Arkla Exploration	1-27 Hoffpauner
87	27-29N-13W	Conoco Inc	27-1 Rudolpert
88	21-13N-18W	Arkla Exploration et al	1 Beauchamp
89	5-14N-16W	McCulloch Oil	1-5 Schimmer
90	10-15N-16W	Southern Union Prod	1 Jones Drake
91	25-18N-11W	Seneca Oil	1-25 Meier
92	33-20N-9W	Rodman Corp	1-33 Maggie Malone
93	1-21N-9W	Mobil Producing	1 Mc Kinzie
94	6-21N-8W	Harper Oil	1 Hundley
95	16-22N-8W	Atlantic Richfield	2 State of Oklahoma
96	8-23N-7W	Davis Oil	1 Eiffel
97	8-25N-5W	C E Dinsmore	1-8 Fothergill
98	5-26N-5W	Conoco Inc	5-2 Conoco
99	6-27N-4W	Indian Wells	1-6-1A Bale

CROSS SECTIONS BASED ON GAMMA-RAY, DENSITY, AND RESISTIVITY LOGS SHOWING STRATIGRAPHIC UNITS OF THE WOODFORD SHALE, ANADARKO BASIN, OKLAHOMA

By
Timothy C. Hester, Howard L. Sahl, and James W. Schmoker
1988

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