UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Lithofacies Description and Interpretation of Selected Intervals in the upper part of the Ordovician Simpson Group in a core from the Mazur Well, Southeast Anadarko Basin, Oklahoma

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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INTRODUCTION

Extensive drilling in the Anadarko Basin, a major hydrocarbon-producing basin in Oklahoma, has yielded a large collection of cores of Paleozoic rocks. The core described here is from the Sunray Parker DX No. 1 Mazur well, and consists of rocks from the middle part of the Early Ordovician Arbuckle Group and the upper part of the Middle Ordovician Simpson Group. The Mazur well is located in the southeast Grady County (sec. 1, T. 3 N., R. 5 W.) in the southeastern part of Anadarko Basin (fig. 1). The well is in the Knox oil field where Ordovician gas is produced from the McLish and Bromide Formations below depths of 15,000 feet (Petroleum Information, 1982).

The purpose of this study is to describe the lithofacies observed in some core from the upper part of the Simpson Group in the Mazur well, and to interpret the environments of deposition. The rock units were described for their lithology, sedimentary structures, trace and body fossil contents, and nature of contacts. The lithologic descriptions are based mainly on analysis of grain size and color, and a general relative estimate of quartz composition of the sandstones. In addition, geophysical log responses (e.g., gamma, sonic, neutron, resistivity, conductivity, and density) were evaluated in relation to lithologic properties.

STRATIGRAPHY

The interval of the Simpson Group studied in the Mazur core includes parts of the McLish, Tulip Creek, and Bromide Formations. Figure 2 is a generalized stratigraphic column of the Simpson Group in the Arbuckle Mountains (Ham, 1969; Johnson and others, 1984). The Arbuckle stratigraphic section has been used by Schramm (1964) and Borras (1979) as reference to the Simpson rock units in the Anadarko Basin. Although the lithologies in the Mazur core are similar to those of the Arbuckle section, the Mazur core contains less limestone and thicknesses of units vary.

The upper 220 ft of the McLish Formation was cored in the Mazur well; this represents the upper one-third of the formation (fig. 3). The formation is composed of interbedded sandstone, conglomeratic sandstone, siltstone, mudstone, and limestone. The sandstone and conglomeratic sandstone represent the bulk, or about 60 percent, of the rock types. The McLish Formation grades upward into the Tulip Creek Formation, which is 235 ft thick; the uppermost 55 ft of the cored interval is missing (fig. 3). The Tulip Creek Formation consists of sandstone, conglomeratic sandstone, siltstone, mudstone, and limestone. The formation contains about 90 percent sandstone and conglomeratic sandstone. The Bromide Formation, which is 295 ft thick, overlies the Tulip Creek Formation (fig. 3). The contact between the two formations was not observed due to a 50-ft missing interval in the lower part of the core of the Bromide Formation. The formation includes a lower member that is 125 ft thick and an upper member which is 170 ft thick. The members of the Bromide Formation consist of interbedded sandstone, siltstone, mudstone, and limestone. The formation contains about 35 percent sandstone that is concentrated in the upper part of the lower member and randomly distributed in the upper member.

In general, the Simpson Group study interval contains about 60 percent sandstone and conglomeratic sandstone. The interval is more sandy compared to other areas in the Anadarko Basin in which the McLish Formation contains as much as 25 percent sandstone, the Tulip Creek Formation includes as much as 100 percent sandstone, and the Bromide Formation consists of as much as 35 percent sandstone (Borras, 1979).

Geophysical logs.--Various geophysical logs were available for portions of the Mazur well. Available logs of suitable quality in the interval of principal interest were digitized in order that the log curves could be compared with the lithology observed in the cores. Gamma, sonic, and neutron logs display the most graphic response to changes in lithology in the core described (fig. 4); log response, as shown in figures 3 thru 8, may be compared with the lithologies illustrated in core photos included in appendix A (1-14).

Sands, or sandy intervals, are clearly visible on the gamma-ray logs, as are dark, waxy mudstones. The only log available through the cored interval to the total depth of the hole is the gamma-ray log; it indicates that, with the exception of the Oil Creek Formation, a few sands are found below the McLish Formation.

CORE LITHOFACIES

Sandstone lithofacies.--The white to gray sandstone varies from very fine to medium grained to conglomeratic. The conglomeratic sandstone consist of granule- to pebble-size clasts of quartz, mudstone, siltstone, limestone, and fossil (brachiopods and crinoids) fragments. The clasts occur either as basal deposits in the sandstone or scattered throughout the sandstone. Basal contacts are sharp to erosional; multiple erosional contacts (appendix B; 1) occur in the sandstones. The white sandstone lithofacies is well sorted, quartzose (greater than 85 percent quartz) arenite, and is locally calcareous, or calcite cemented. The gray sandstone or litharenite lithofacies is less quartzose and contains a higher proportion of rock fragments than the quartz arenite. The white, quartzose arenites are more common than the gray litharenites.

The sandstone lithofacies consists of cross laminated, ripple laminated, parallel laminated, and convoluted (fig. 5; appendix B, 2, 3, and 4). These sedimentary structures show the following combinations of vertical sequences: 1) cross laminations in the lower part and ripple laminations in the upper part of the sequence; 2) parallel laminations in the lower part and ripple laminations in the upper part of the sequence; and 3) multiple successions or series of cross laminations and ripple laminations as well as parallel laminations and some convolutions. Inclination of cross laminations show bimodal orientation and range from 5° to 20°. The cross laminations range from 2 to 11 in. in thickness. The laminations of the sedimentary structures are commonly defined by layers of macerated fine organic fragments. The sandstone lithofacies contains many bioturbated units (appendix B, 5) that are interbedded with cross laminations, ripple laminations, and parallel laminations. The burrows are nondescript horizontal and vertical tube-like structures; the vertical burrows are more common than the horizontal burrows.

Siltstone lithofacies.--The lithofacies is dark gray to light gray to white where the siltstone is quartzose (appendix B, 6). The siltstone lithofacies shows gradational upper and lower contacts where they are interbedded with the mudstone lithofacies. However, where the lithofacies is overlain by the sandstone lithofacies, the contact is erosional. The siltstone lithofacies is commonly ripple laminated (asymmetrical ripple laminations; appendix B, 7). Flaser bedding is developed where the siltstone is intercalated with the mudstone lithofacies. Here pinstripe burrows are formed in the mudstone that bind the flasered units (appendix B, 8). Unidentifiable horizontal and vertical burrows are common in the siltstone lithofacies. Horizontal bioturbation is more common in this lithofacies than in the sandstone lithofacies. Fragments of crinoid and brachiopod shells commonly occur as lenses in this lithofacies.

Mudstone lithofacies.--The mudstone lithofacies is waxy, dark gray to black; the latter containing abundant finely-divided organic fragments (appendix B, 9). The contacts with most adjoining rock types are gradational; when overlain by the sandstone lithofacies the contat is erosional. Most mudstone is calcareous or limy. The lithofacies is locally fissile and splintery and may correctly be classified as muddy shale. The sedimentary structures include laminations which stand out where the core has been weathered. Occasionally the lithofacies is interlaminated with thin, white, quartzose silty units which form parallel and ripple laminations. However, most of the primary structures of the mudstone lithofacies have been obliterated by bioturbation (appendix B; 10). Trace fossils, (*Planolites*, *Trichophyens*, and *Dictyodora*) are common burrows in shales and mudstones of the Bromide Formation (Longman, 1981). Most of these animal burrows are interpreted as feeding traces. In addition to trace fossils, body fossils of transported and abraded crinoid and brachiopod fragments are found.

Limestone lithofacies.--The lithofacies is light to dark gray and the contacts with adjoining rock types are generally gradational and sharp. The limestone (appendix B, 11) varies from micrite to biomicrite (Folk, 1959). Most of the limestone is nodular or lumpy bedded (appendix B, 12). The nodules are as much as 2 in. thick and 3 in. long. Longman (1981) suggested that nodular-bedded limestones in the Bromide Formation are caused by concentrations of shell fragments. The nodules are white biosparites bounded by dark gray micrite. Nonbedded limestone consisting of sparse biomicrite is also present.

Most of the sedimentary structures of the limestone lithofacies are spar- and micrite-filled tubular vertical and horizontal burrows and burrow-mottles. V-shaped dessication mud cracks (appendix B, 13) perpendicular to bedding plane, filled by micrite or sparite, are present (appendix B, 13). infilled by either micrite or sparite. Some clasts in the limestone facies appear to have been derived from the mud cracks. Shell fragments of brachiopod and crinoid fossils (appendix B, 14) are the most important bioclasts of the lithofacies, and occur concentrated in lenses or scattered throughout the lithofacies. Stylolites, which represent a late diagenetic feature due to compaction, are common in the limestone lithofacies. A few small-scale cross laminations were observed in the lithofacies. Fine-grained dolomite is associated with the fossiliferous biomicrite.

VERTICAL LITHOFACIES ASSOCIATIONS

An inspection of the vertical lithofacies sequence shows cyclic repetition of rock types. The lithofacies associations consist of a lower mudstone lithofacies unconformably overlain by the white quartz arenite sandstone lithofacies. In other parts of the study interval, the mudstone lithofacies is overlain by the siltstone lithofacies as well as interbedded with the limestone lithofacies. Thus, where the white quartz arenite unconformably overlies the mudstone facies, it is assumed that the associated siltstone and limestone lithofacies were eroded.

The white quartz arenite-mudstone lithofacies association occurs in the McLish, Tulip Creek, and Bromide Formations. In the McLish Formation, it is as much as 85 ft thick. The sequence is greater than 200 ft thick and makes up almost the entire Tulip Creek Formation. In the Bromide Formation, the lithofacies association is as much as 75 ft thick. In addition, the Bromide Formation contains numerous thin intervals of the quartz arenite-mudstone association ranging from 10 to 40 ft thick. These vertical lithofacies associations, which occur throughout the upper part of the Simpson Group, are typified by three cycles (1, 2, and 3) as shown in figures 5-8.

Cycle 1 (fig. 6), in the Tulip Creek Formation, consists of 10-ft-thick mudstone lithofacies unconformably overlain by 160-ft-thick white quartz arenite lithofacies. The quartz arenite lithofacies consists of multiple erosional-based sandstones that contain granule to pebble-size particles or conglomeratic sandstones. The lithofacies contains a few thin limestones. The sandstone units range from 2 to 40 ft in thickness and each unit contains a succession of cross laminations, parallel laminations, and ripple laminations frequently interrupted by burrowed units.

The basal mudstone of cycle 1 is represented by a distinctive peak on the gamma-ray log (figs. 3, 6). Although core is missing from this interval, the top of the cycle, on the basis of log response, is probably at a depth of approximately 16,160 ft below the surface (fig. 3).

Cycle 2 (fig. 7), 75 ft thick, is developed in the lower member of the Bromide Formation. The lithofacies association includes a 30-ft-thick mudstone lithofacies that is burrowed, silty, and fossiliferous in the lower part and grades upward into a 5-ft-thick burrowed, rippled, quartzose siltstone lithofacies interbedded with mudstone lithofacies. The siltstone lithofacies, in turn, is unconformably overlain by the white, quartz arenite lithofacies that is 35 ft thick; the uppermost 5 ft is a scoured-based sandstone. The internal structures are a succession of cross laminations and ripple laminations separated by bioturbated zones. The uppermost scour-based quartz arenite contains lag deposit of shells of crinoid and brachiopod fossils.

Cycle 2 (fig. 7) is not as clearly defined as cycle 1 by gamma-ray response; individual units/beds are thinner, and it is difficult to place precise cycle boundaries on the basis of log response.

Cycle 3 (fig. 8), about 30 ft thick, formed in the upper member of the Bromide Formation. The lithofacies association consists of 8-ft-thick burrowed mudstone lithofacies grading upward into a 1-ft-thick rippled, quartzose siltstone lithofacies. The siltstone lithofacies is unconformably overlain by 15-ft-thick white quartz arenite lithofacies that displays internal scouring. The arenite is, in turn, conformably overlain by flaser-bedded quartzose siltstone (2 ft thick) and a calcareous, quartz arenite (4 ft thick).

The scale of bedding in cycle 3 (fig. 8) is small enough that logs are of very limited utility in defining cycles.

INTERPRETATION

The precursor of the Anadarko Basin was an aulacogen (Hoffman and others, 1974) The aulacogen in southern Oklahoma began with a graben stage of block faulting followed by volcanism and graben-filling (Late Proterozoic-Middle Cambrian). The area evolved into a subsiding basin by Late Cambrian to Early Devonian (fig. 9). Longman (1981) proposed that the Simpson Group was deposited in this subsiding basin. He suggested that the McLish, Tulip Creek, and Bromide Formations were deposited during pulses of subsidence. Between periods of subsidence the aulacogen filled with sediments which passed into a gently dipping terrigenous mud-dominated subtidal ramp merging with adjacent borderlands. During deposition of the Bromide Formation on this subtidal ramp along the northeast side of the basin, Longman (1981) proposed the development of a basin-forebuildup-buildup-lagoon carbonate platform. Shale was deposited in the basin, micrite in the forebuildup, biosparite in the buildup, and micrite and shale in the lagoon. The lagoonal environment of this carbonate platform probably served as the major depositional setting for the Simpson Group in the Mazur core site.

The cyclic deposits of mudstone-siltstone and quartz arenite lithofacies probably represent cycles formed during seaward outbuilding or progradation of quartz arenites into the lagoonal environment. The mudstone-siltstone-limestone lithofacies is interpreted as mainly subtidal lagoonal deposits. The flaser bedding in the siltstone lithofacies suggests deposition perhaps in the lagoonal tidal flat environment (Reineck and Singh, 1980). Here tidal fluctuations provided sedimentation of silt during waxing stage and mud sedimentation during waning stage. Reworking of the sediments by feeding animals, prevalent during the waning stage, caused bioturbation. The dessication mud cracks in the limestone suggest deposition in the intertidal environment where subaerial exposure contributed to drying of carbonate muds.

The quartz arenite lithofacies, which contains erosional bases, internal multiple scours, and conglomeratic units, suggest deposition in a channel. The types and succession of sedimentary structures of the quartz arenite are similar to those observed by Kumar and Sanders (1975), Hayes and Kana (1977), and de Mowbray and Visser (1984) in subtidal channel deposits. The lag conglomeratic sandstones consisting of reworked clasts and fossil fragments, and cross laminations (e.g. dunes and megaripples) represent channel bottom deposits. The associated ripple laminations and bioturbations reflect structures developed in channel bar deposits; the parallel laminations are structures formed in shallow channel deposits. Tidal flat deposition in the quartz arenite is probably represented by bioturbated units that formed in the uppermost parts of the lithofacies. The multiple scours in the quartz arenite probably represent incised ebb and (or) flood tidal channels.

The abundance of subtidal-channel arenites in the Mazur well suggest either close proximity to the point-source, or in a locus of terrigenous deposition. The point source of these sands, if Schramm (1964) is correct, was from the east--probably transported from the Canadian shield. Thus, proximity to the locus of terrigenous deposition which was influenced by accumulation in a rapidly subsiding basin, seems to be the more appropriate hypothesis. That the subtidal lagoon-intertidal setting in which the Mazur core sediments were deposited was in a subsiding basin is indicated by the location of the Mazur well, which is southwest of the northeastern hingeline of the aulacogen (fig. 9).

ACKNOWLEDGMENTS

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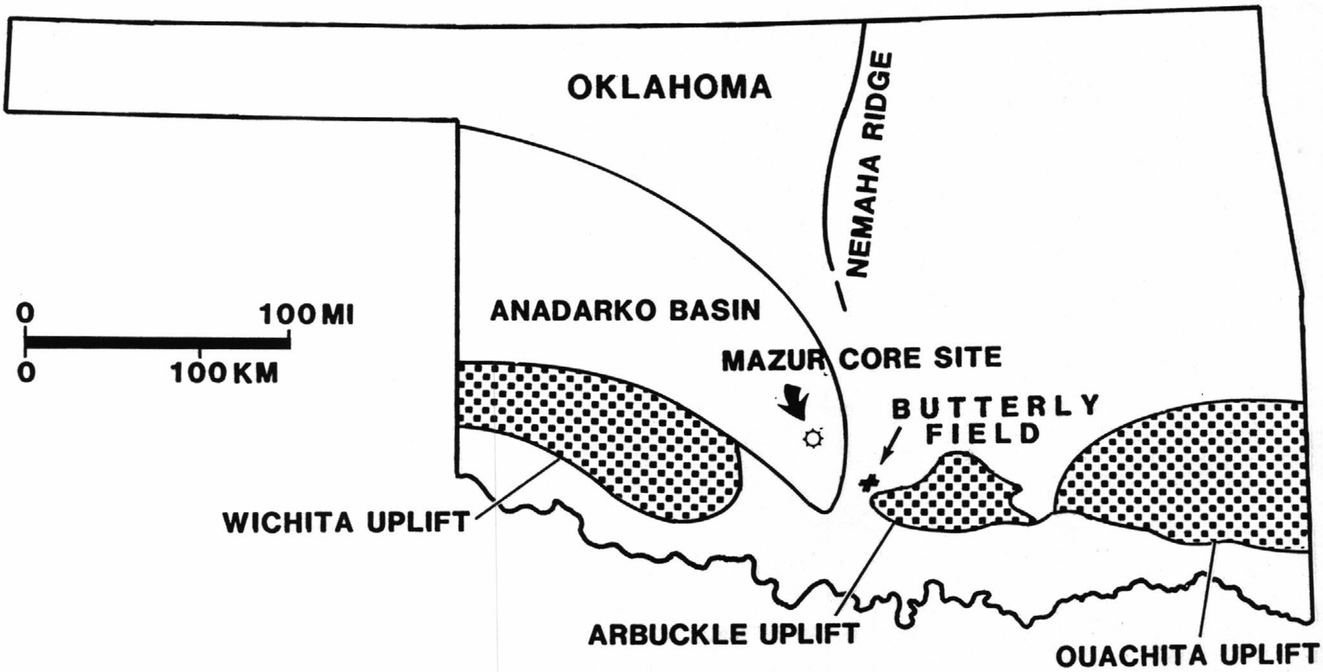


Figure 1. Map showing locality of Mazur well, southeastern Anadarko Basin, Oklahoma, and the Butterly Field (Borras, 1979) in relation to the major tectonic features in the state.

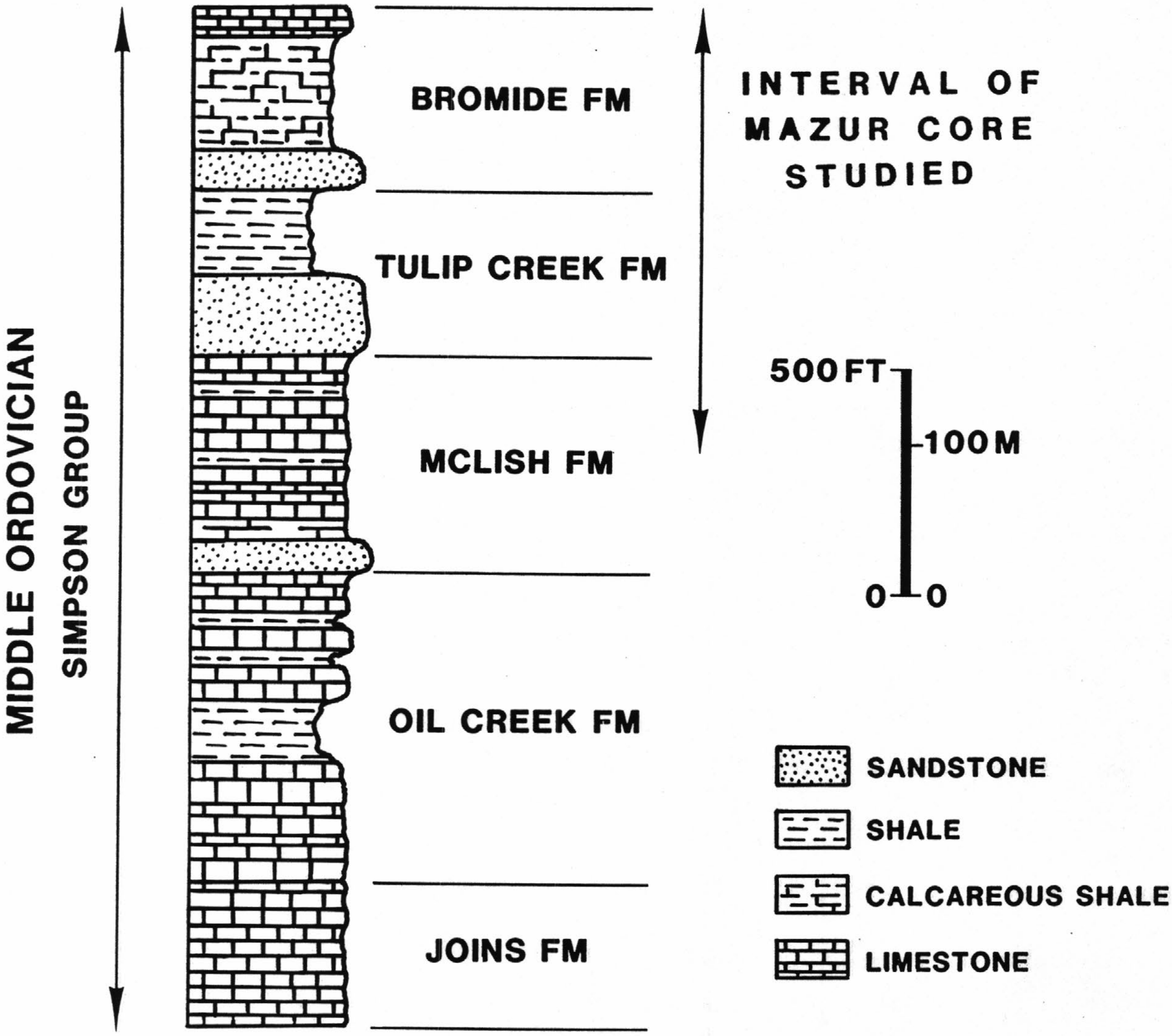


Figure 2. General stratigraphic column, Simpson Group, in the Arbuckle Mountains (Ham, 1969; Johnson and others, 1984). Note differences in thicknesses and lithologies between Arbuckle Mountains site and at the Mazur well.

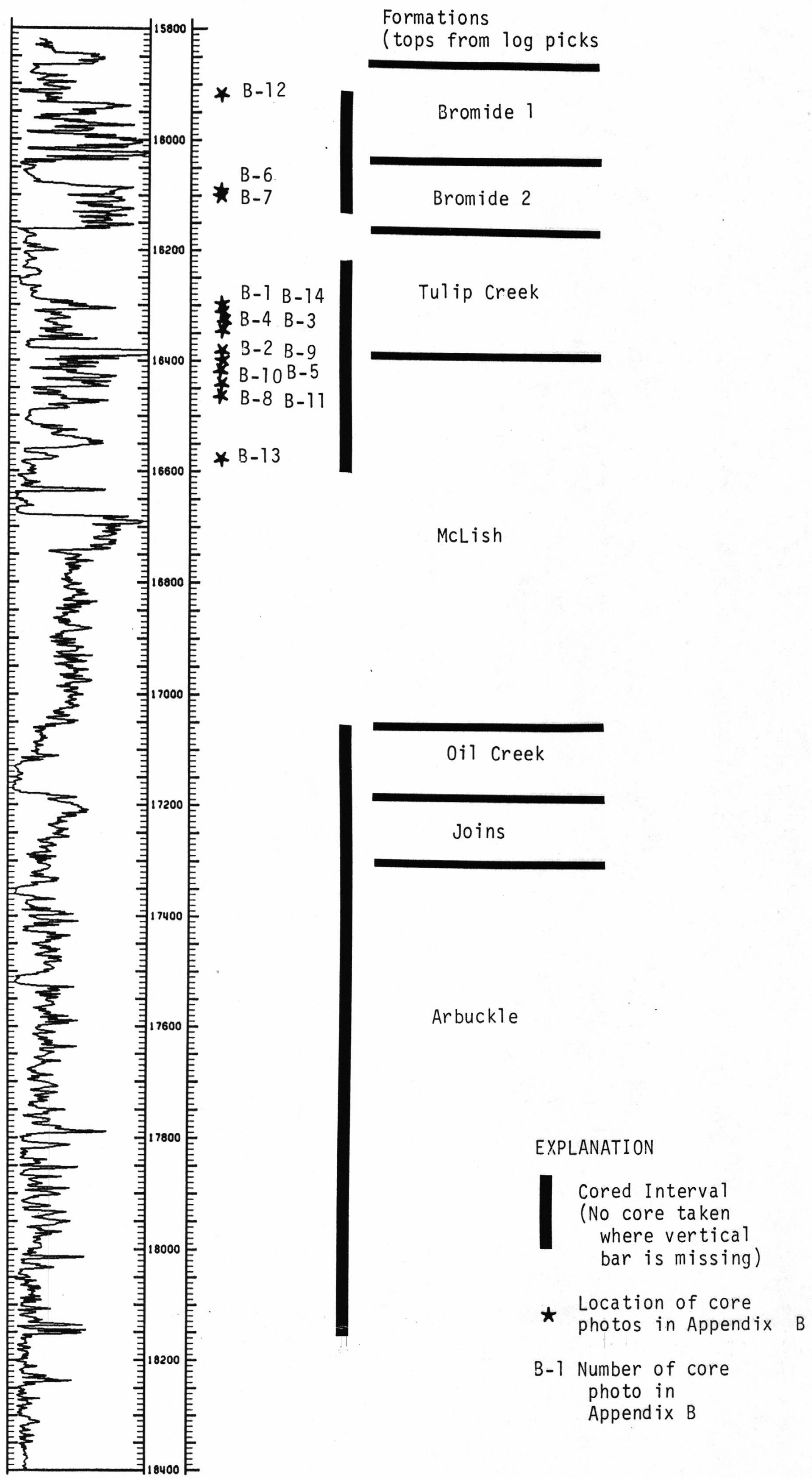


Figure 3. Gamma ray log, to total depth of hole, showing cored intervals and formation tops (picked from logs); stars indicate locations of photos found in Appendix B.

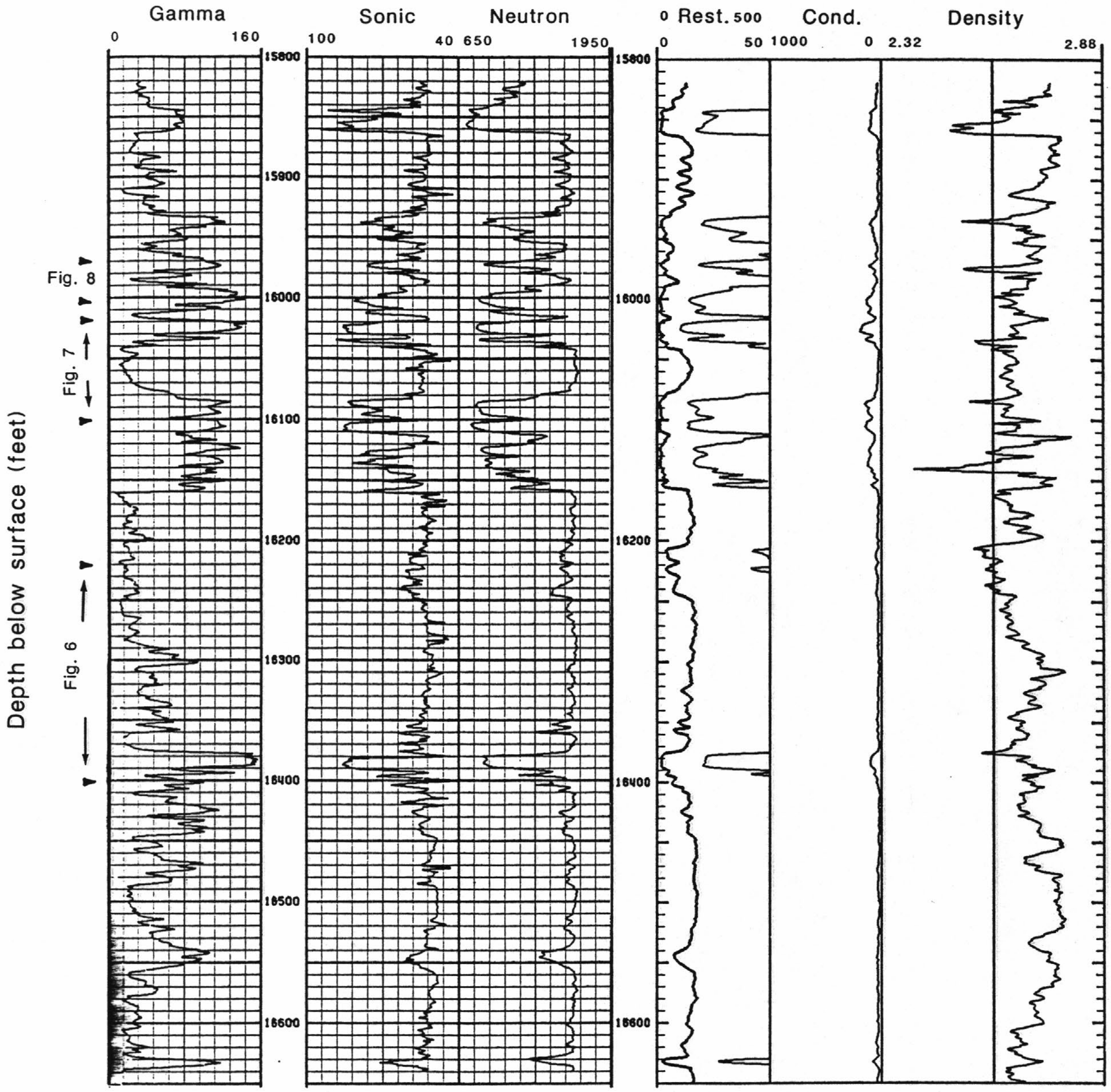


Figure 4. Response of various logging tools through the interval examined for this report. Selected intervals are illustrated in greater detail in figures 5 - 8; location of cycles shown in figures 6 - 8 is marked.

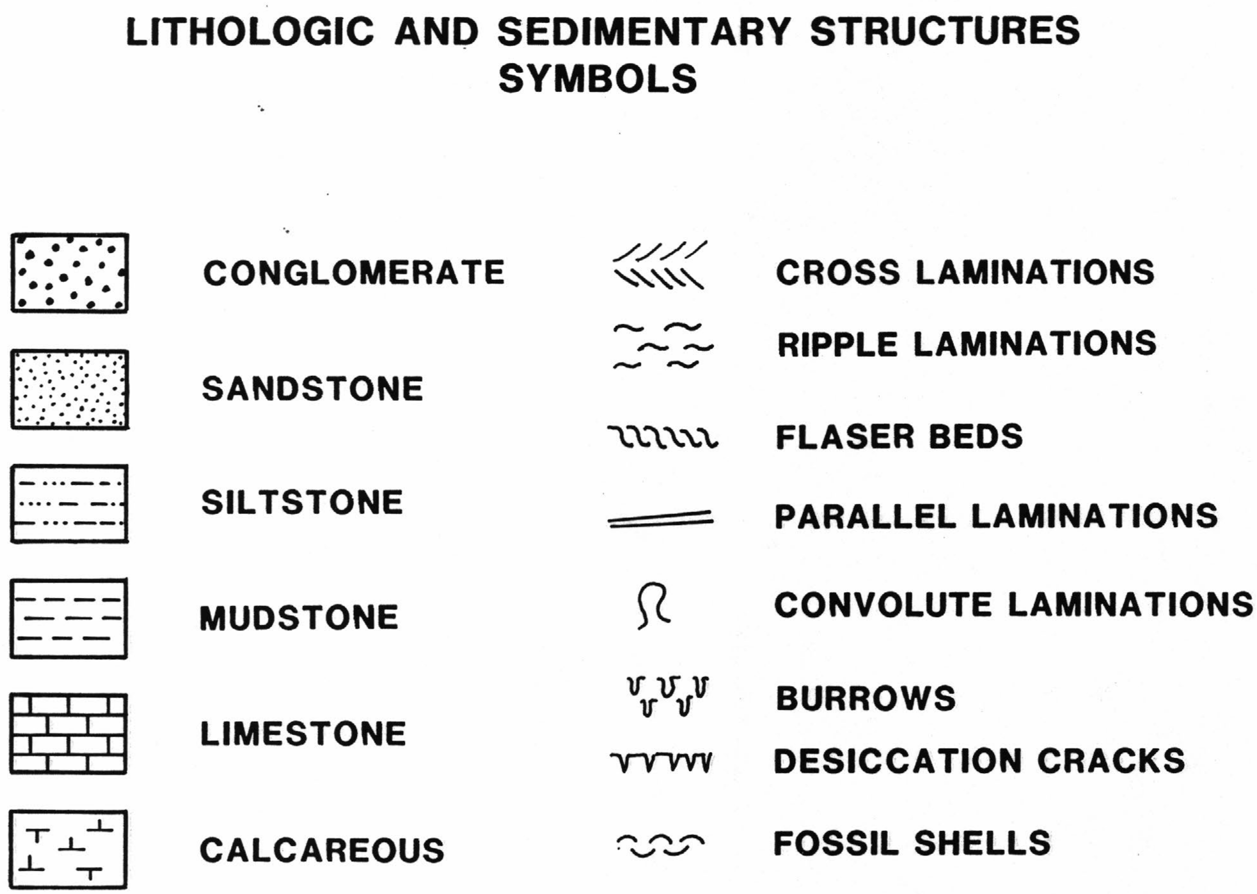


Figure 5a. Explanation for Figures 5 - 8.

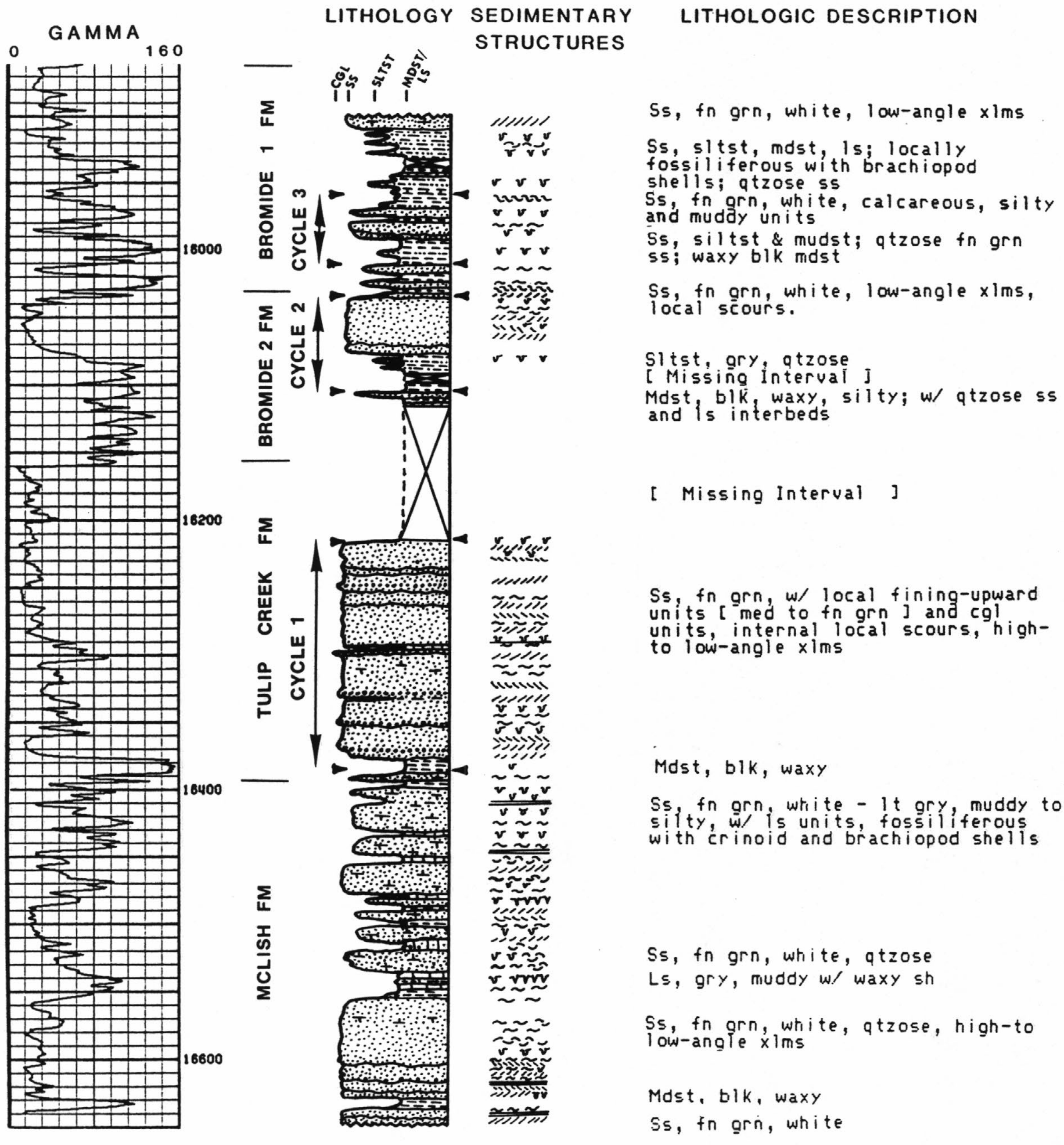


Figure 5. Gamma ray log and description of corresponding cored interval in the McLish Formation into the Bromide Formation, Mazur well.

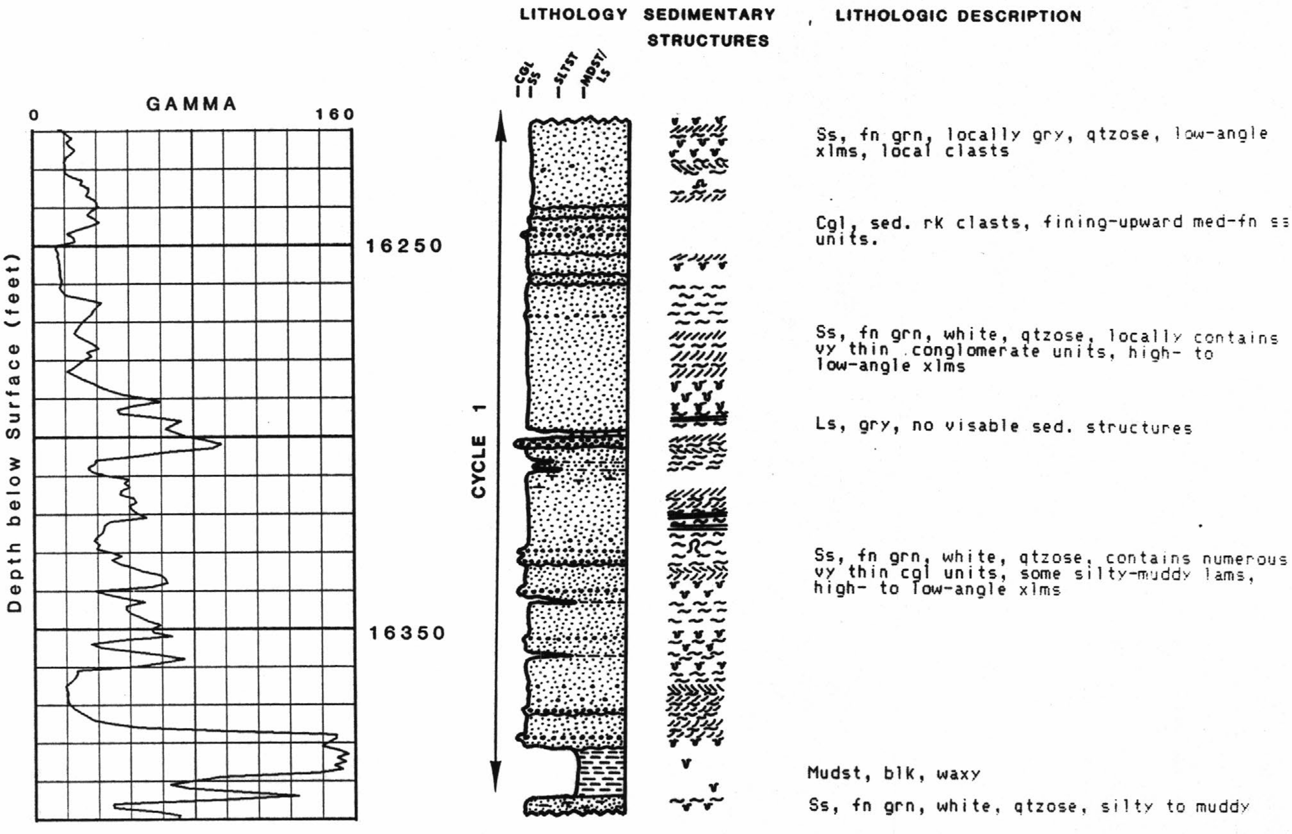


Figure 6. Gamma ray and lithologic log of cycle 1 in the Tulip Creek Formation.

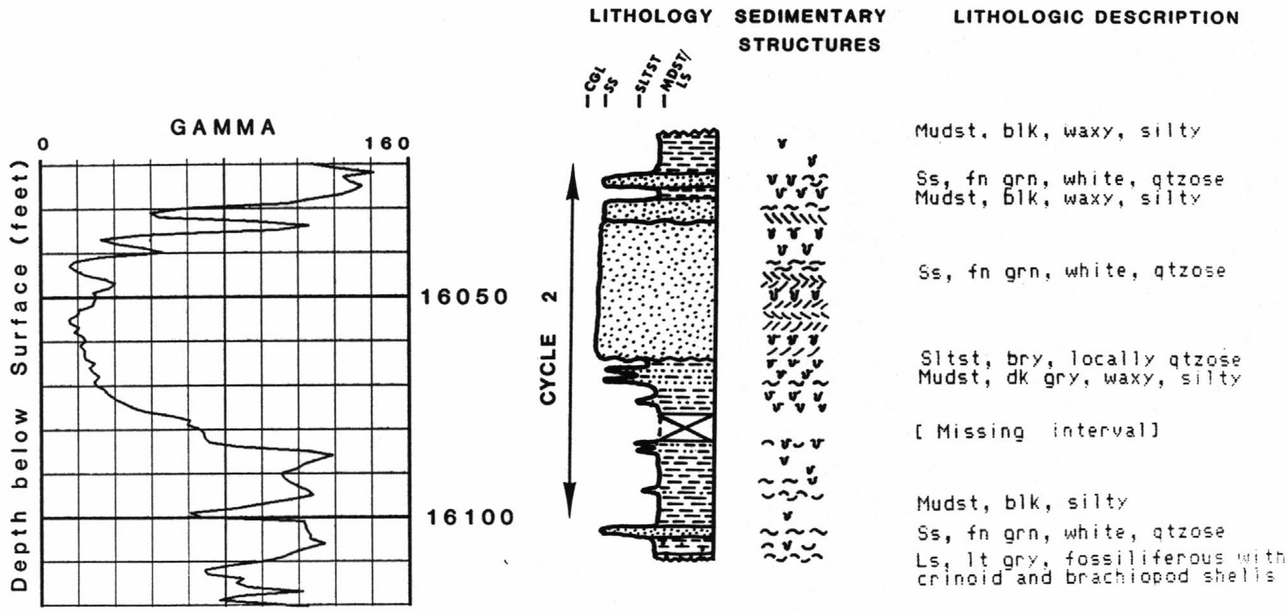


Figure 7. Gamma ray and lithologic log of cycle 2 in the lower member of the Bromide Formation.

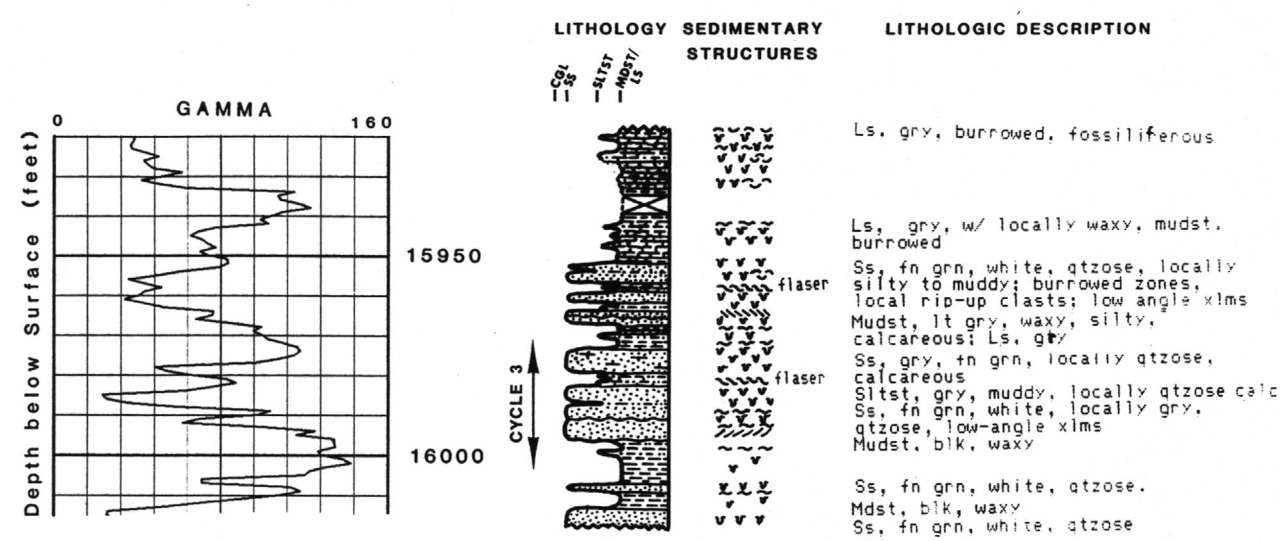


Figure 8. Gamma ray and lithologic log of cycle 3 in the upper member of the Bromide Formation.

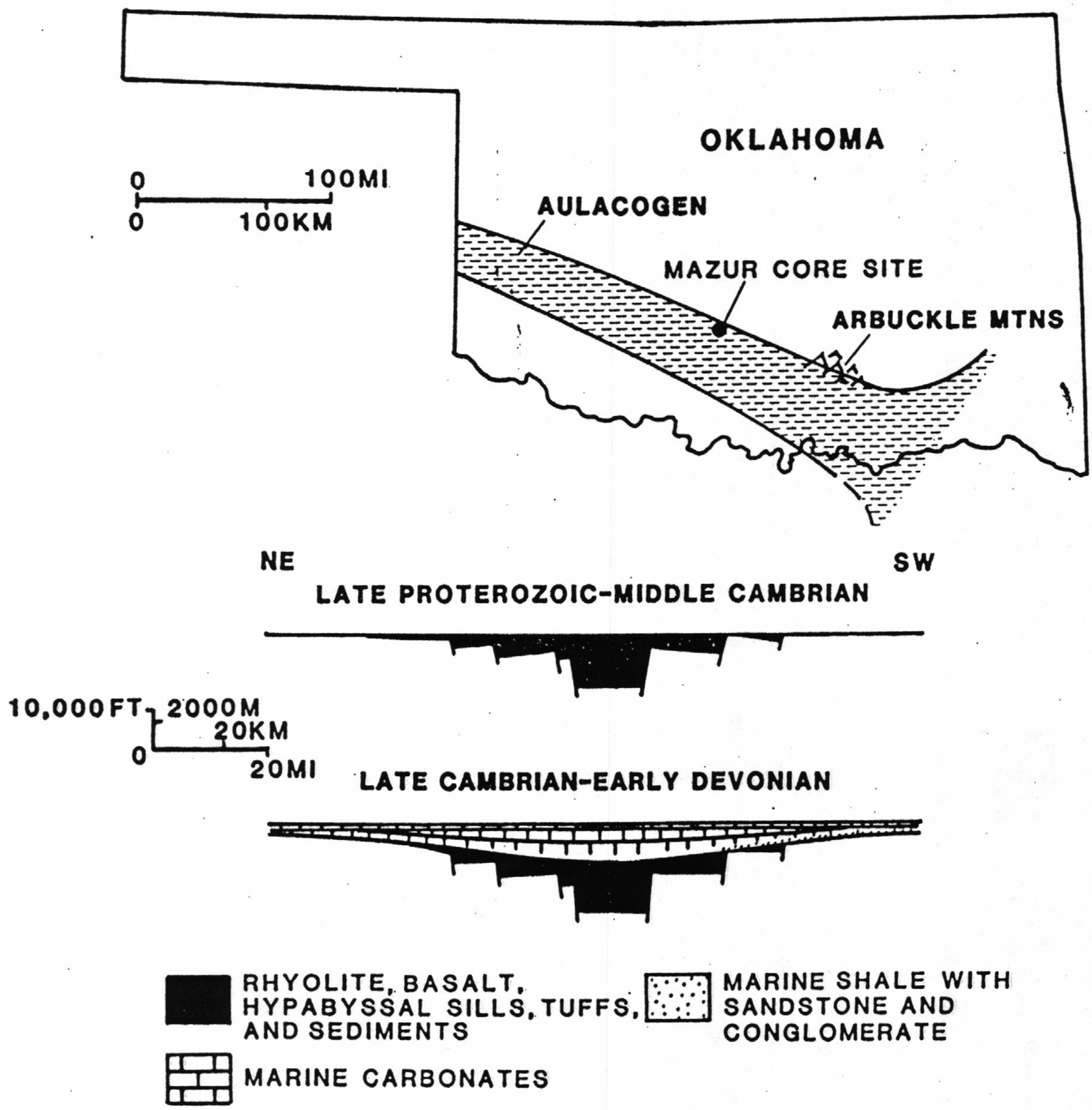
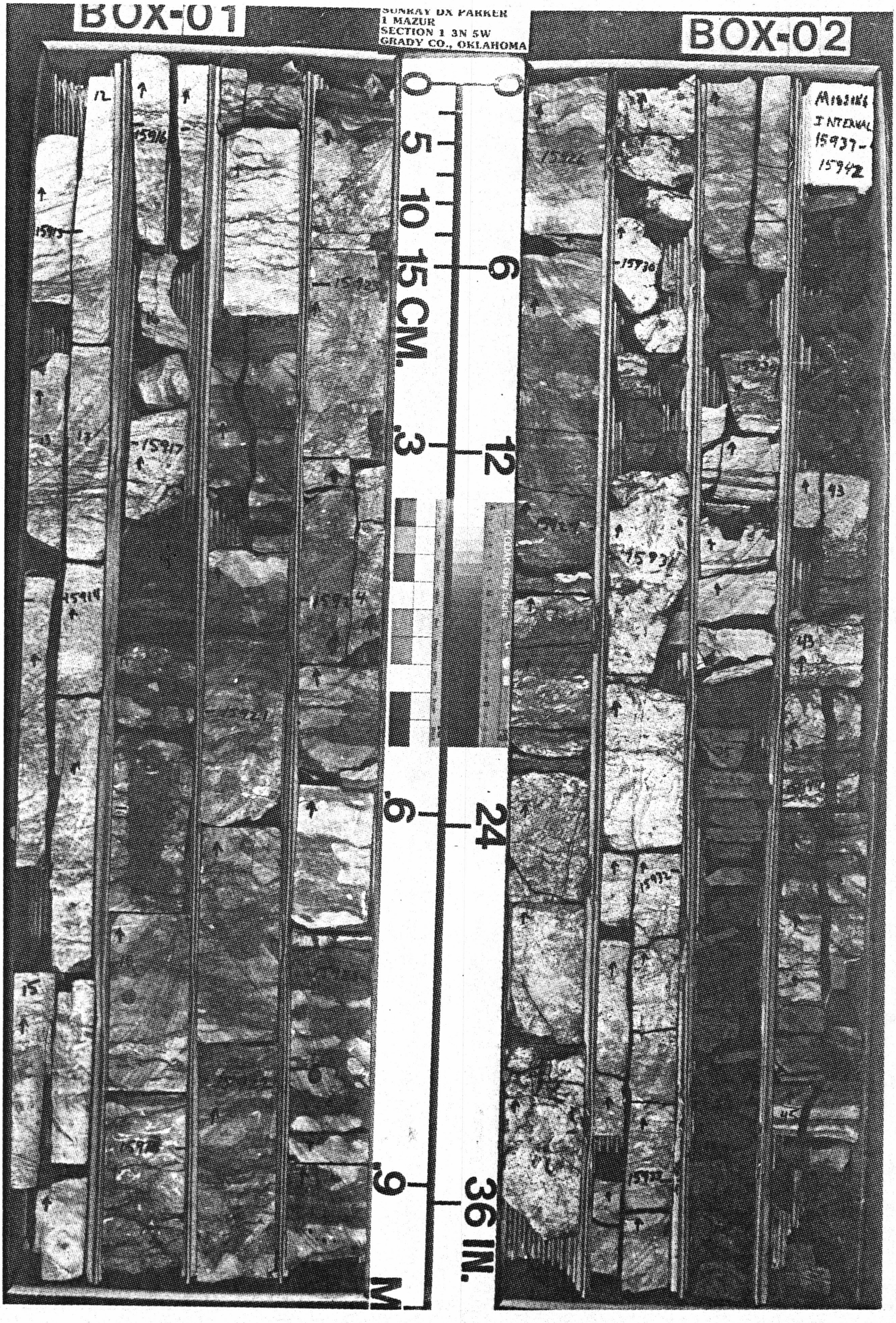
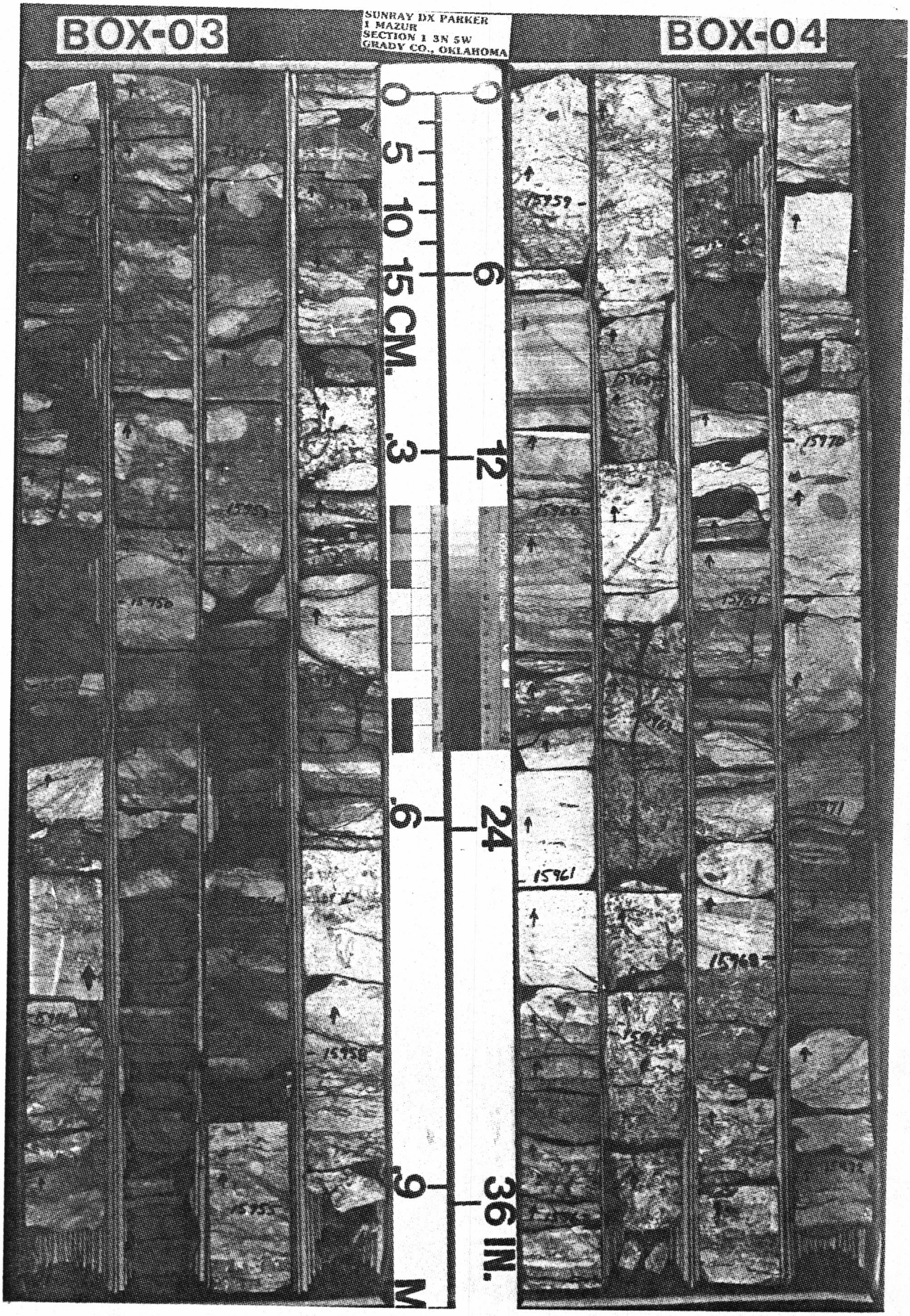
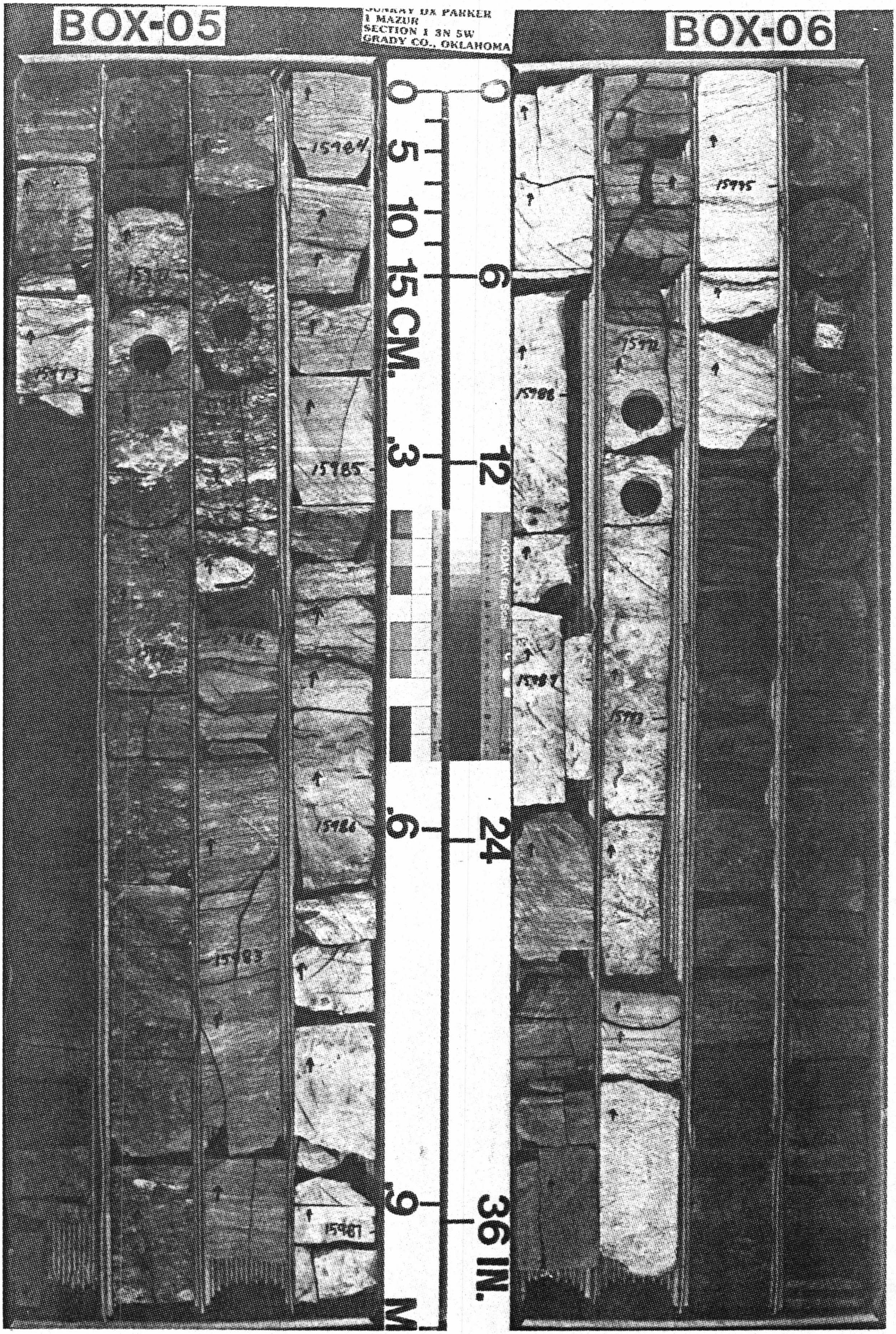


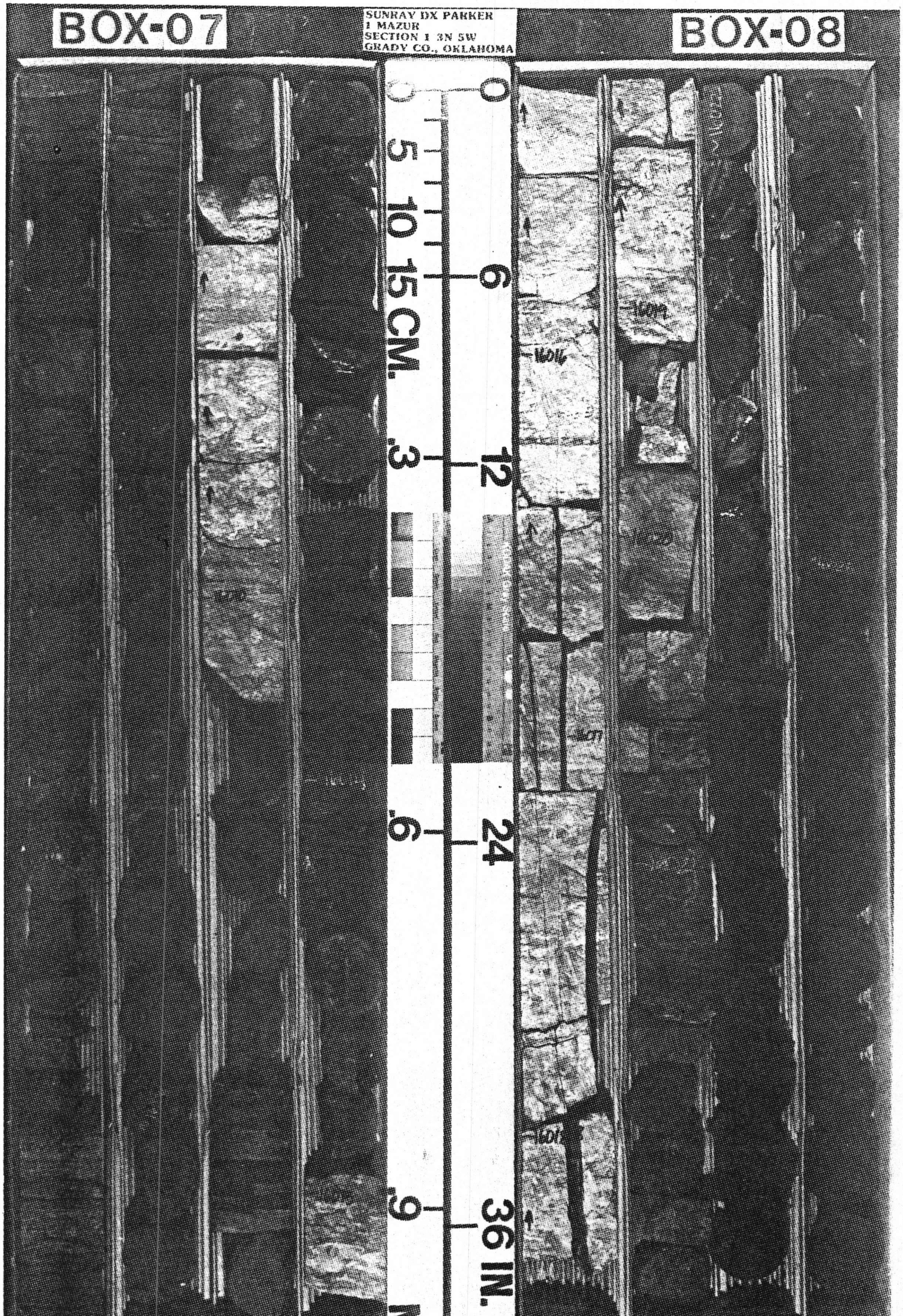
Figure 9. Location of the Mazur drill hole in relation to the aulacogen that existed in southern Oklahoma from late Cambrian to early Devonian time.

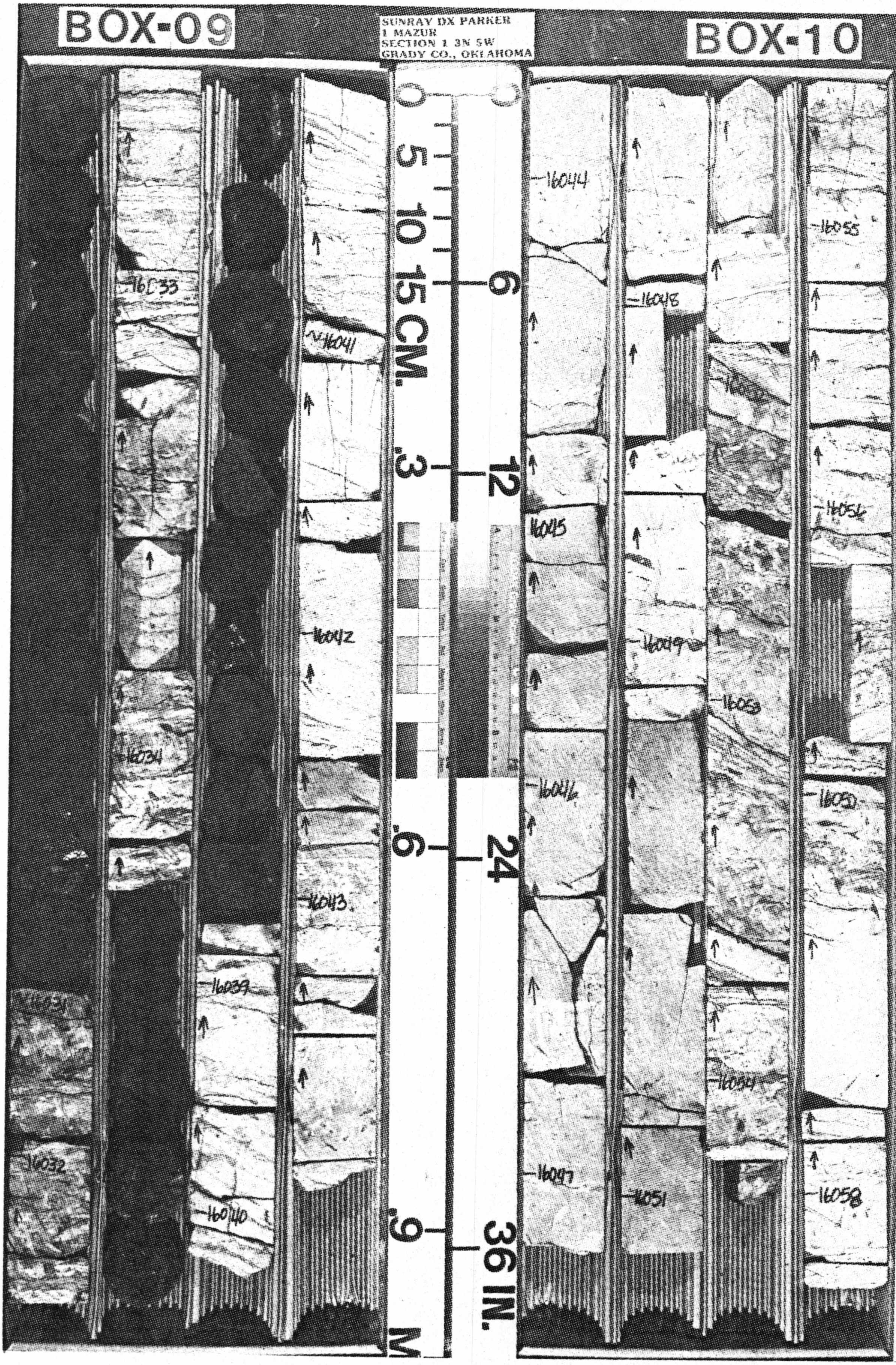
Appendix A. Photos of core recovered from the Mazur well from the McLish Fm. into the Bromide interval from 15,913 feet to 16,413 feet beneath the surface. See figure 5 for a description of the lithology and Appendix B for photos of selected core intervals and/or sedimentary features.


BOX-01
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-02
MISSING INTERVAL 15937-15942
0 5 10 15 CM.
.3
.6
.9
M
6
12
24
36 IN.


BOX-03
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-04
0 5 10 15 CM.
.3
.6
.9
M
6
12
24
36 IN.


BOX-05
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-06


BOX-07
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-08


BOX-09
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-10
5
10
15 CM.
.3
.6
.9
M
6
12
24
36 IN.
16033
16041
16042
16034
16043
16039
16031
16032
16040
16044
16045
16046
16047
16048
16049
16051
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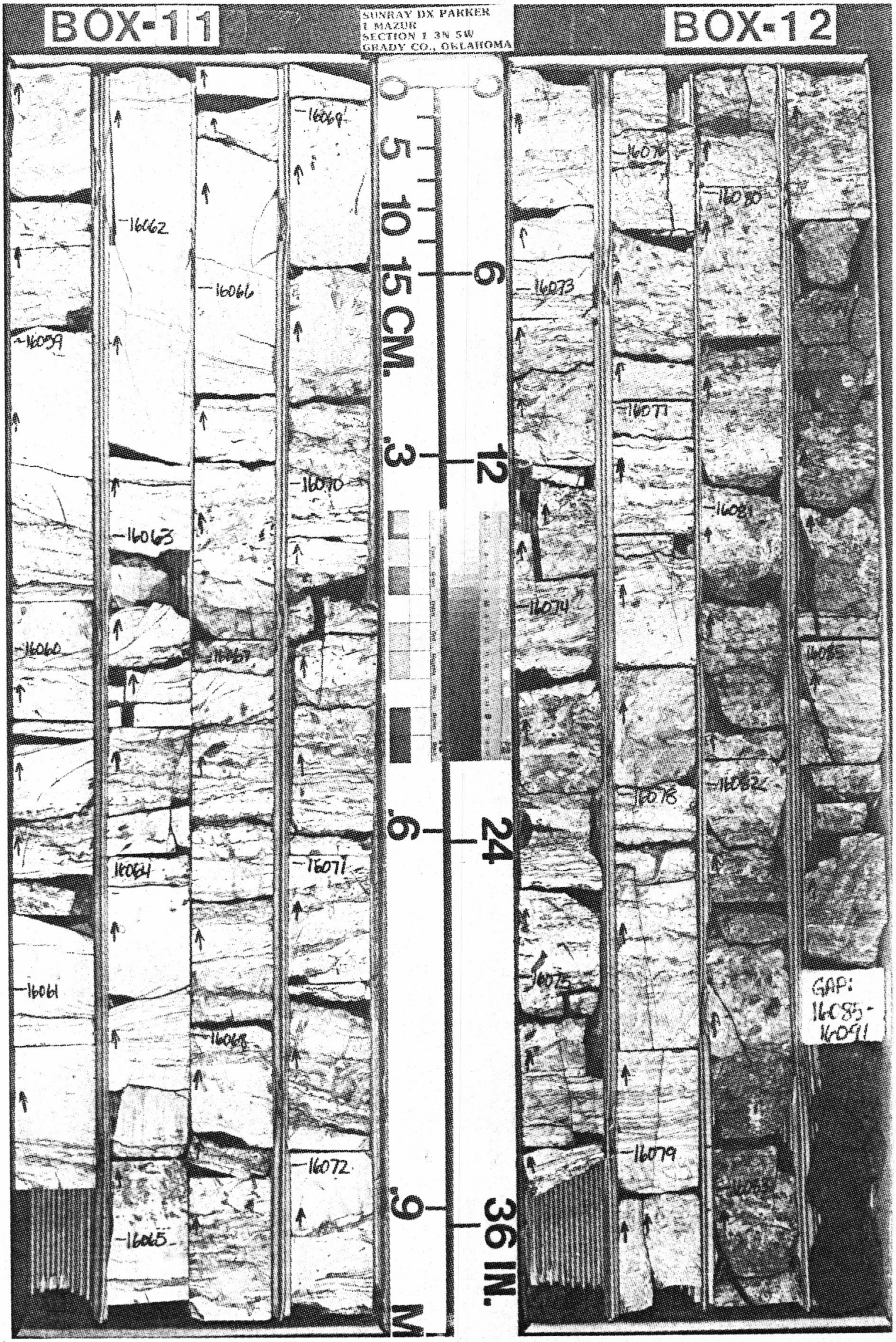
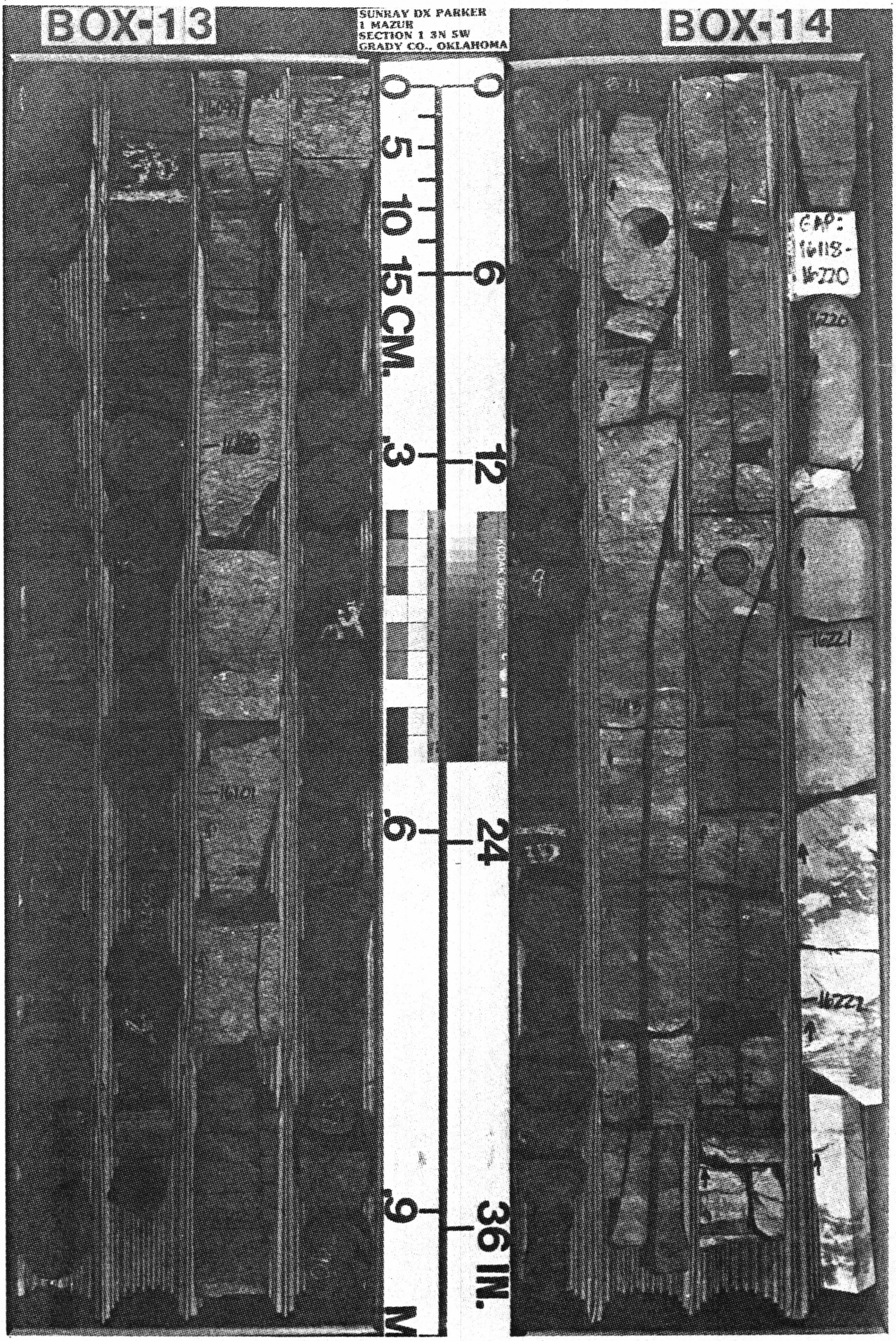
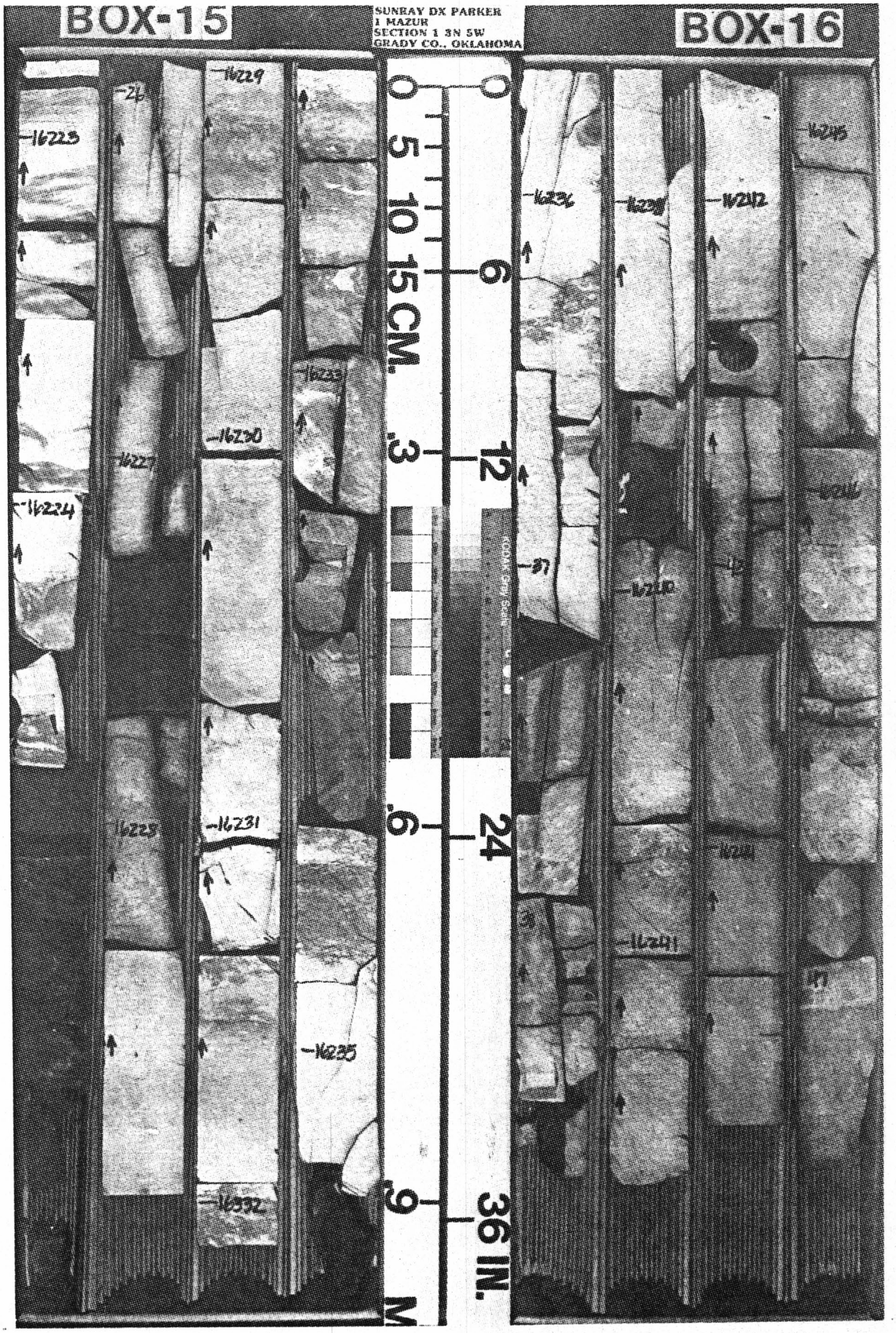
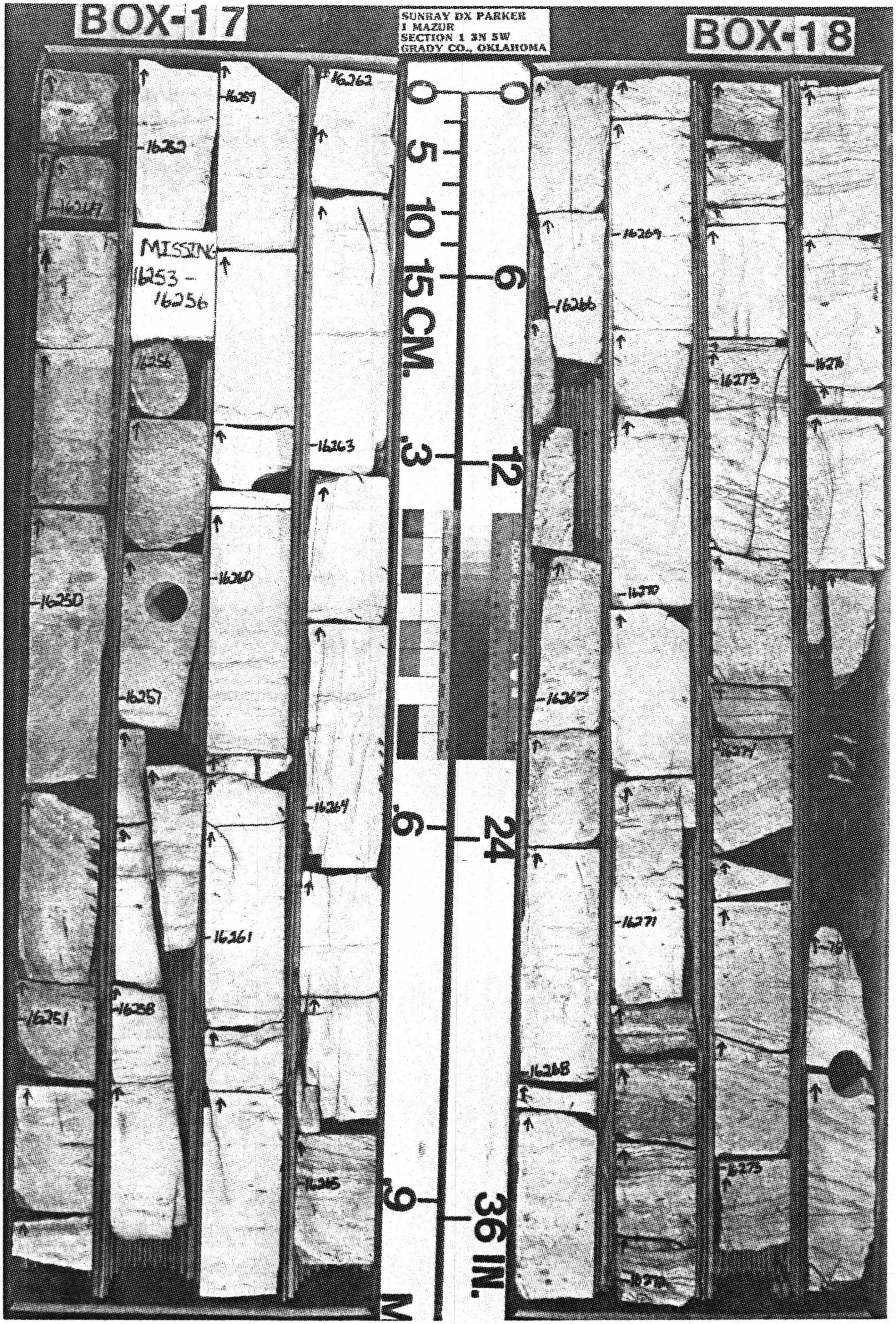
16058

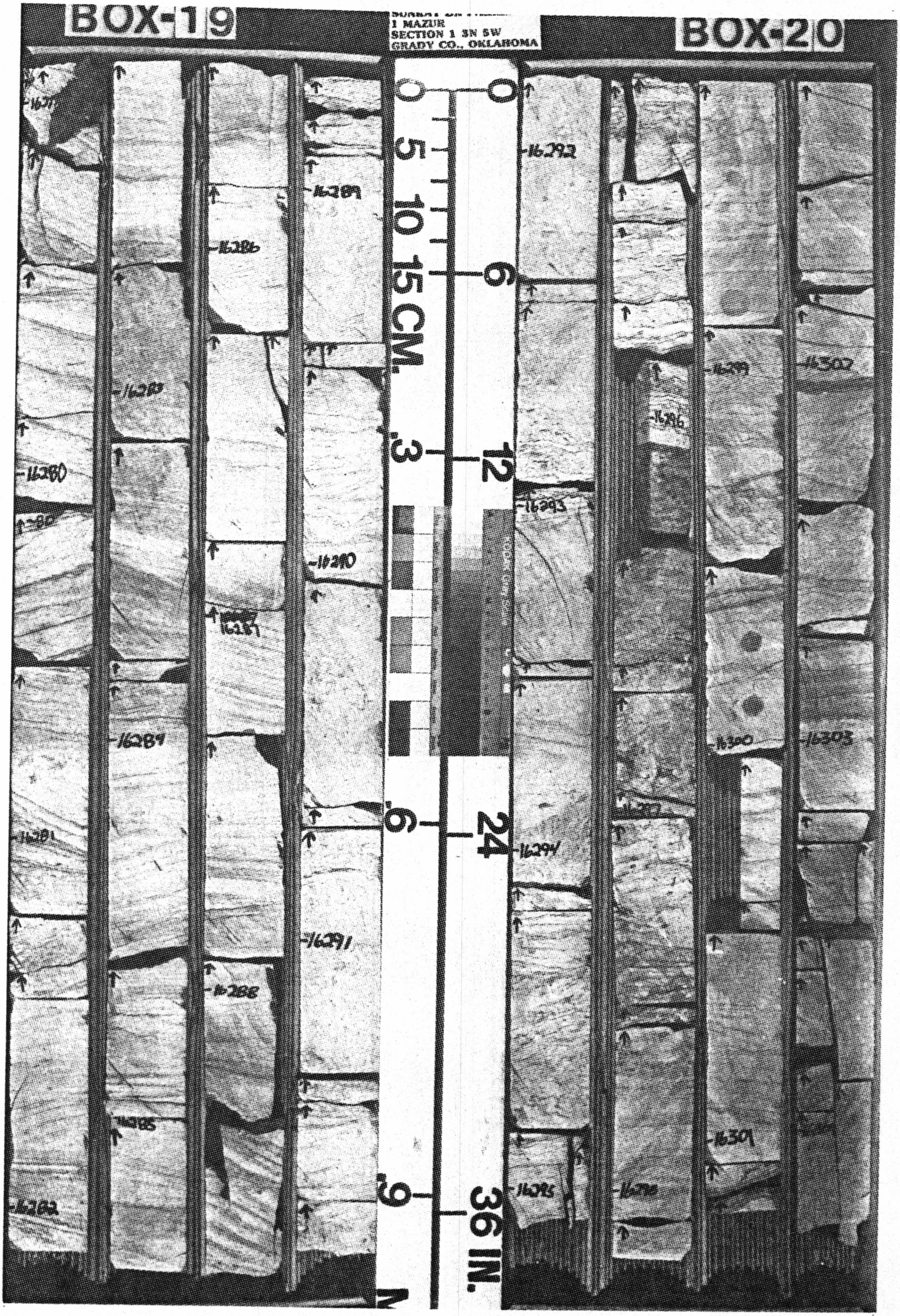

BOX-11
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-12
5 10 15 CM.
.3
.6
.9
M
6
12
24
36 IN.
GAP: 16085-16091

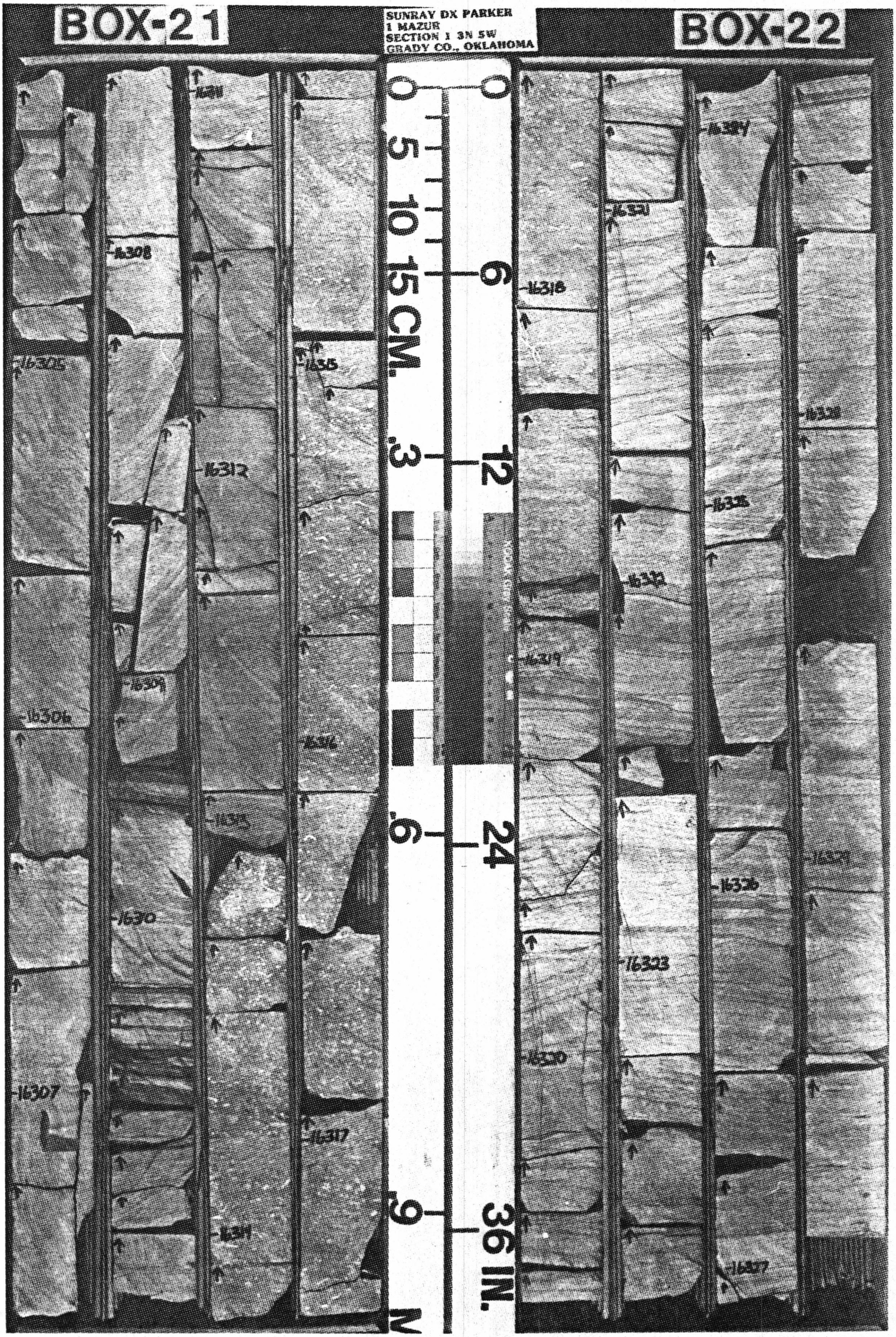

BOX-13
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-14
GAP:
16118-
16220

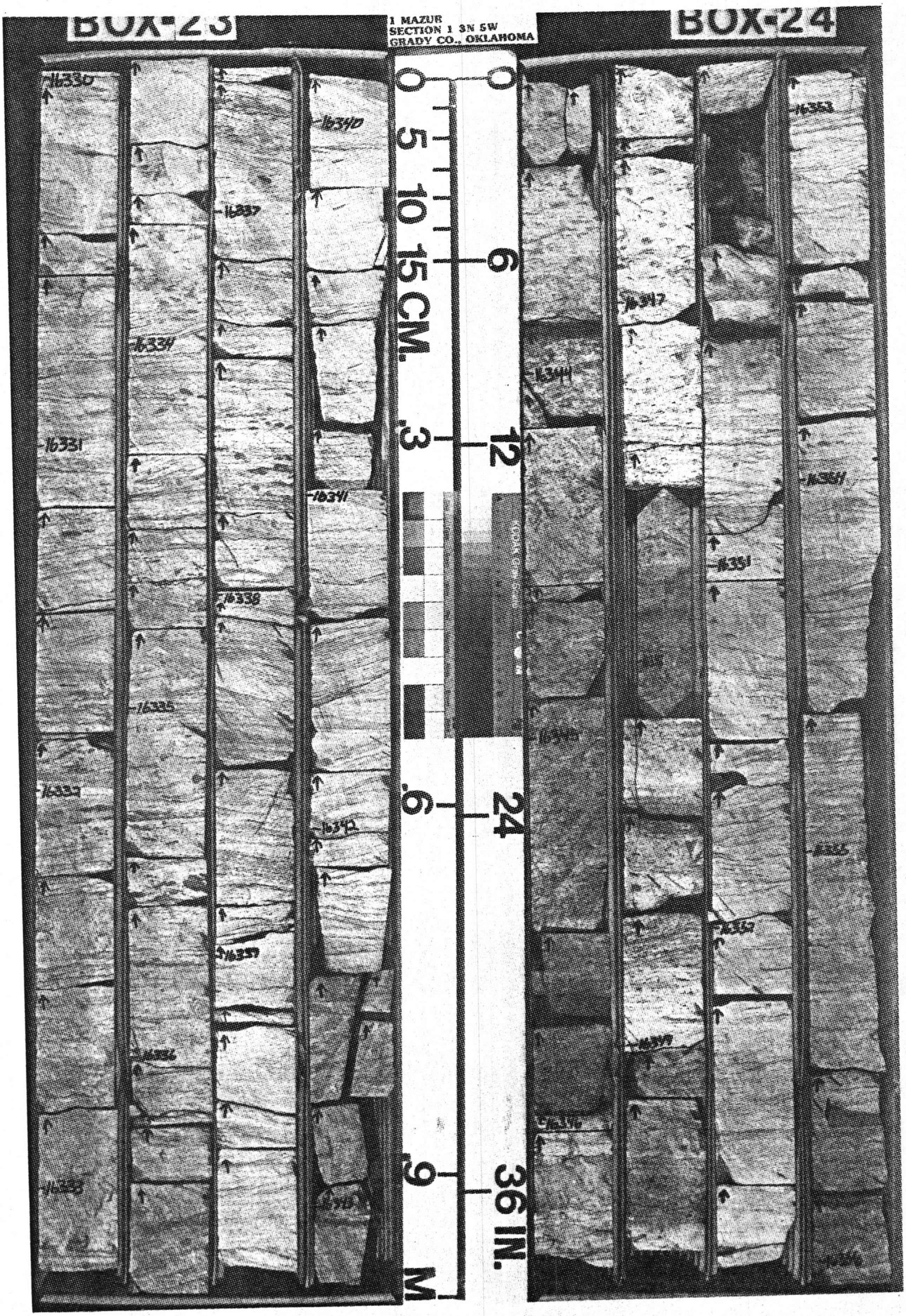

BOX-15
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-16

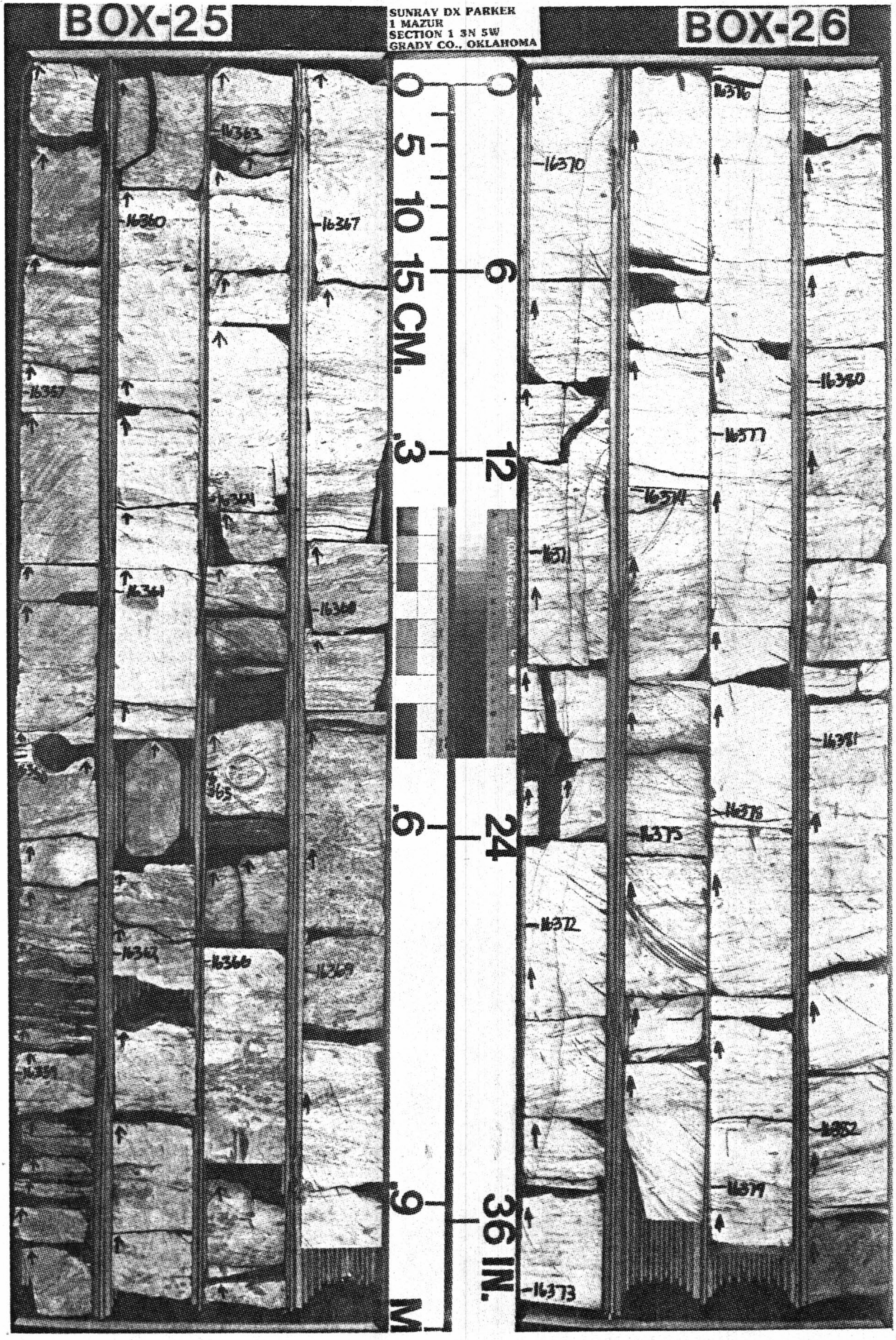


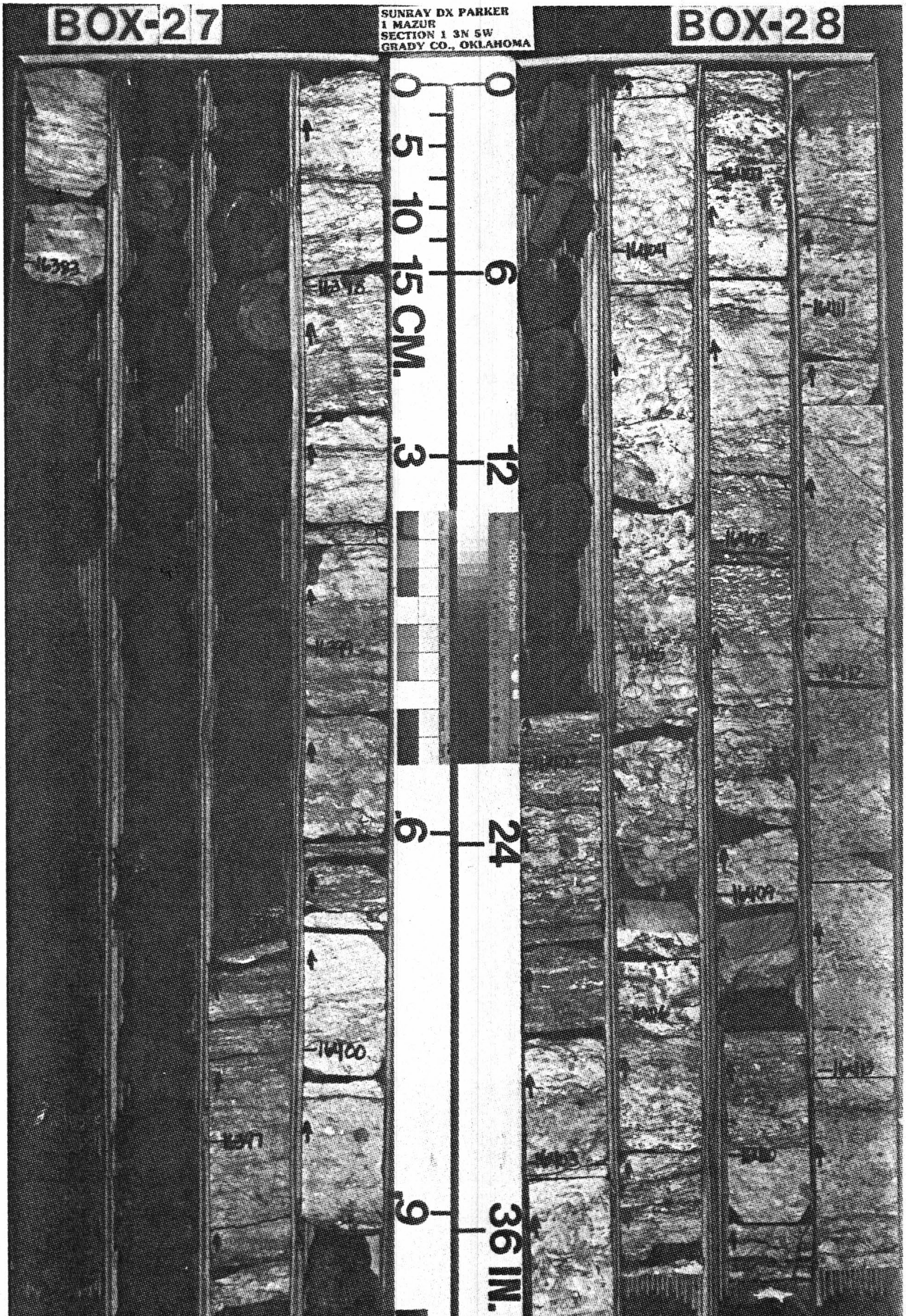
BOX-17
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-18
MISSING
16253 -
16256
15 CM.
36 IN.


BOX-19
BOX-20
I MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
15 CM.
36 IN.

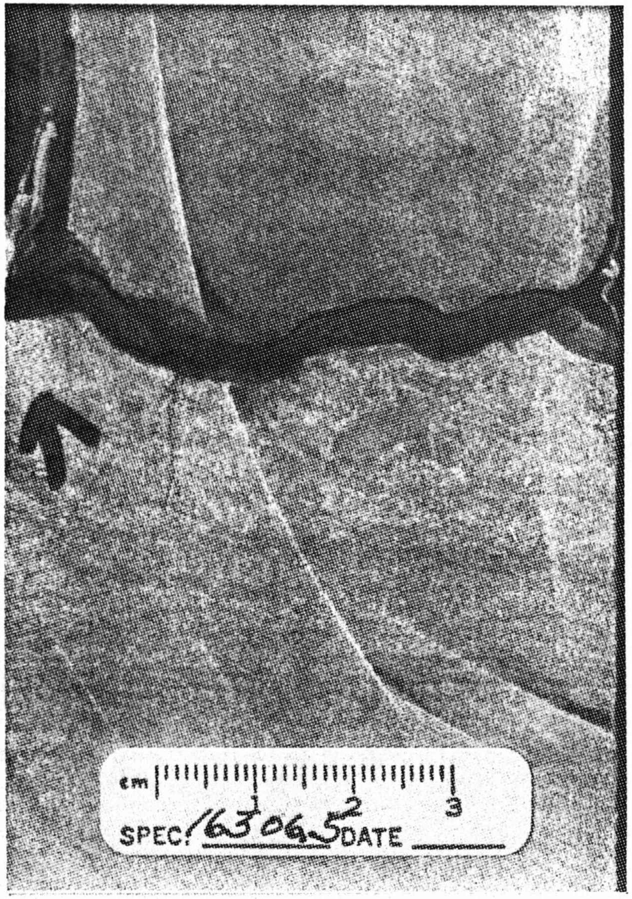

BOX-21
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-22


BOX-23
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-24
0 5 10 15 CM.
6 12 24 36 IN.
.3 .6 .9 M

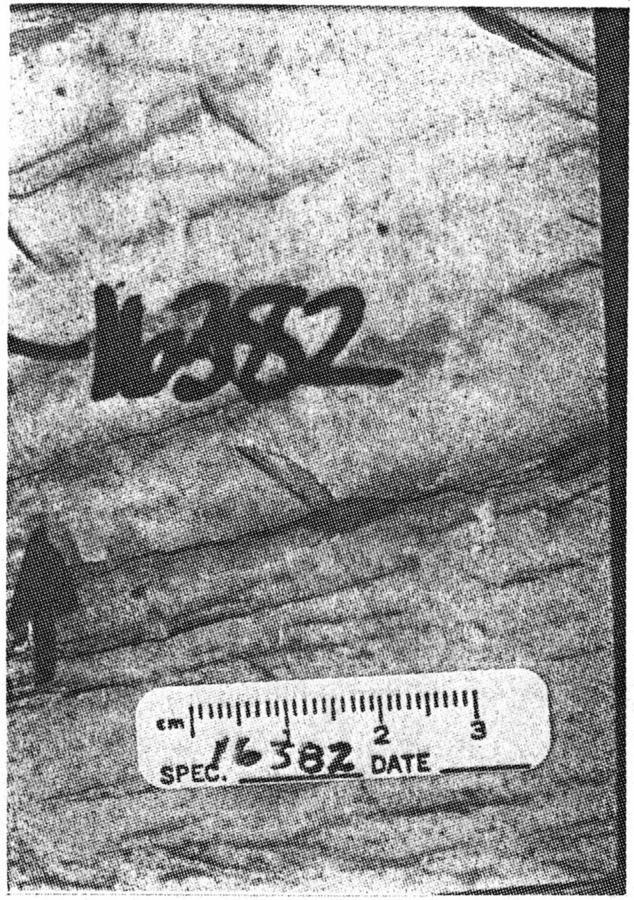

BOX-25
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-26
0 5 10 15 CM.
.3 .6 .9 M
6 12 24 36 IN.


BOX-27
SUNRAY DX PARKER
1 MAZUR
SECTION 1 3N 5W
GRADY CO., OKLAHOMA
BOX-28

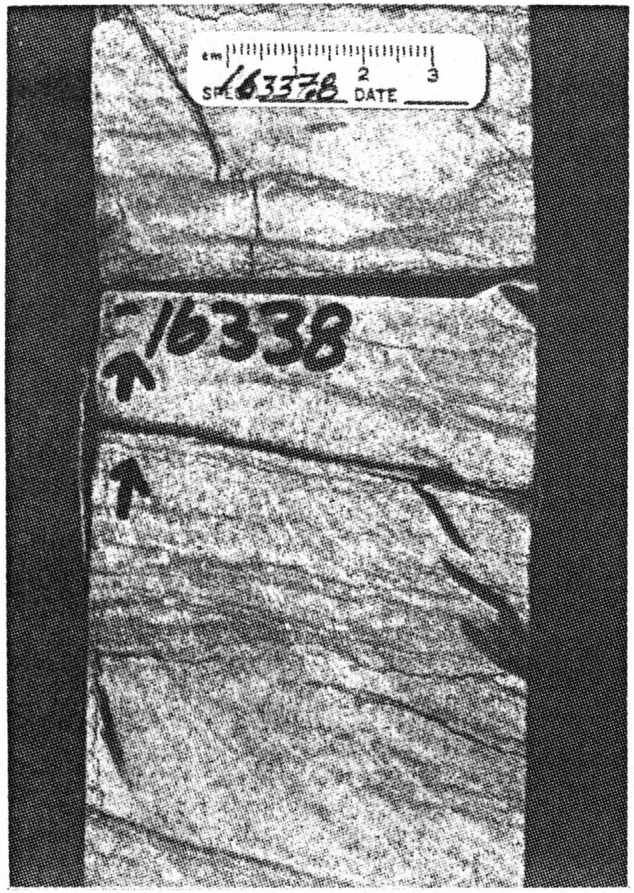
Appendix B. Photographs of selected sedimentologic and/or lithologic features in the core interval described.



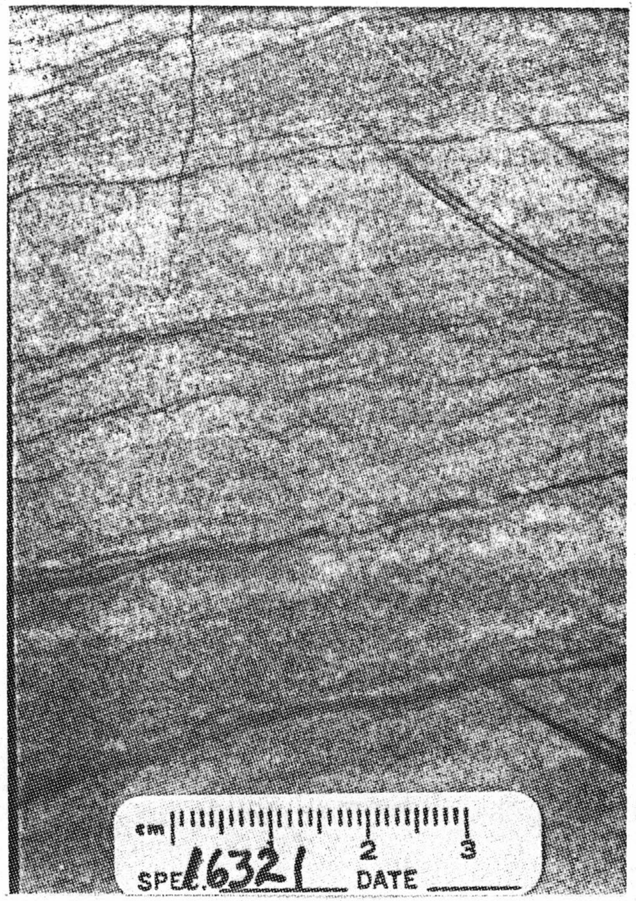
1. Erosional contact (siltstone clast?) in the litharenite facies.



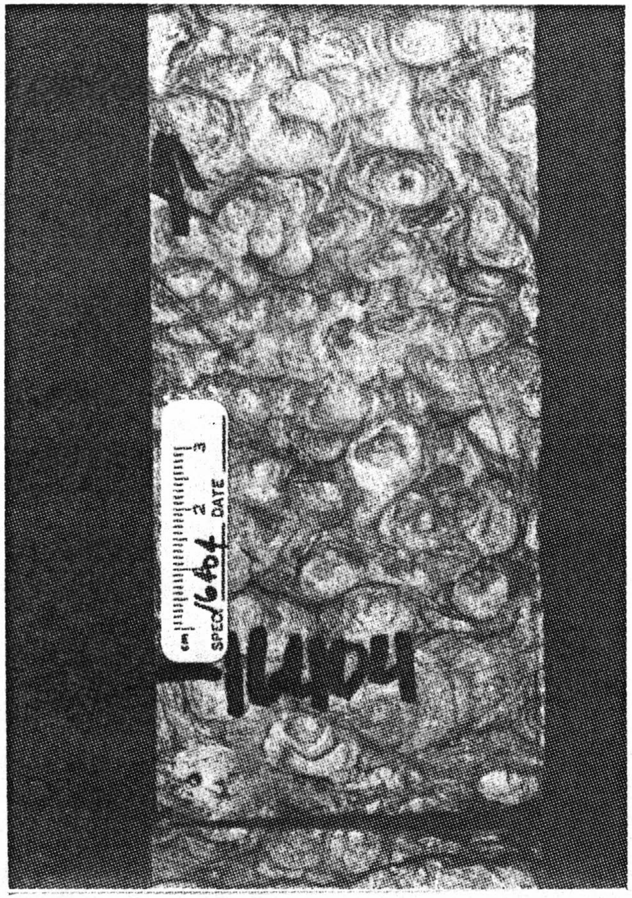
2. High-angle cross lamination in litharenite facies.



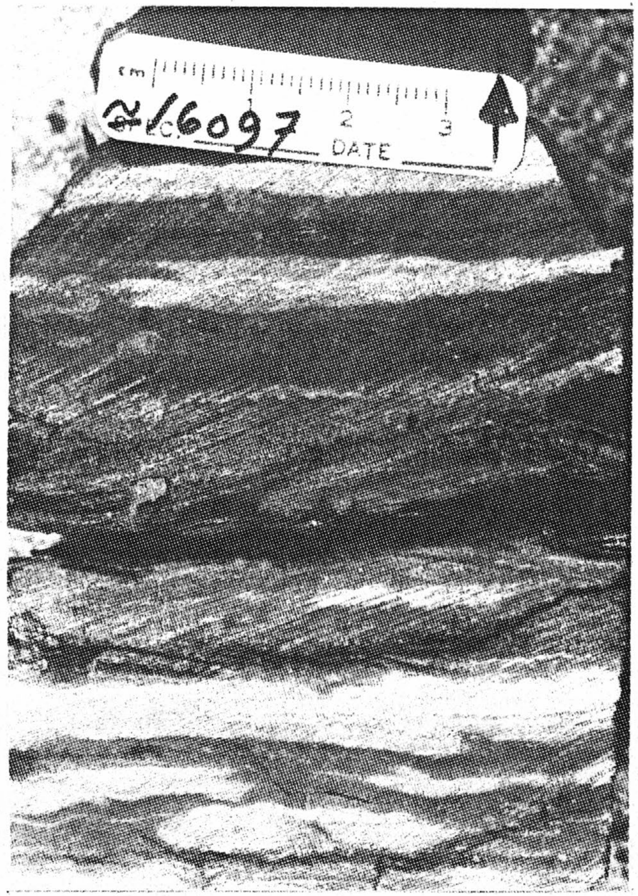
3. Low-angle cross laminations and ripple laminations in the litharenite facies.



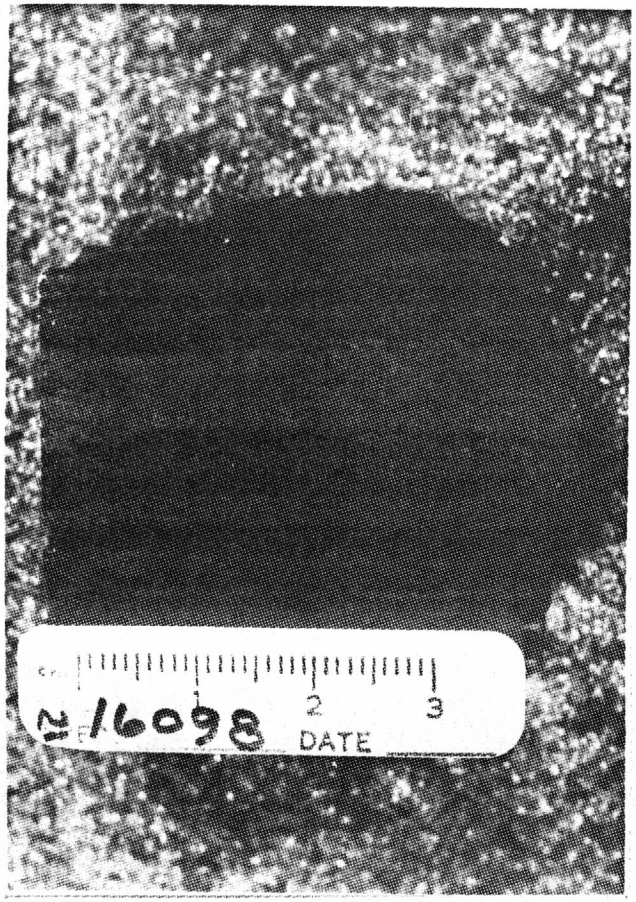
4. Ripple laminations in litharenite facies.



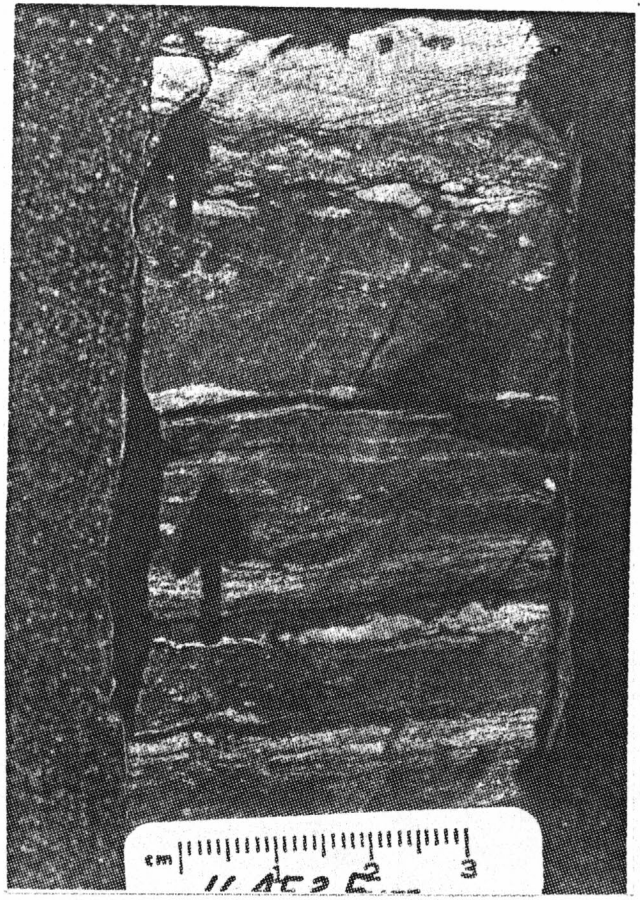
5. Intense bioturbation in sandstone lithofacies.



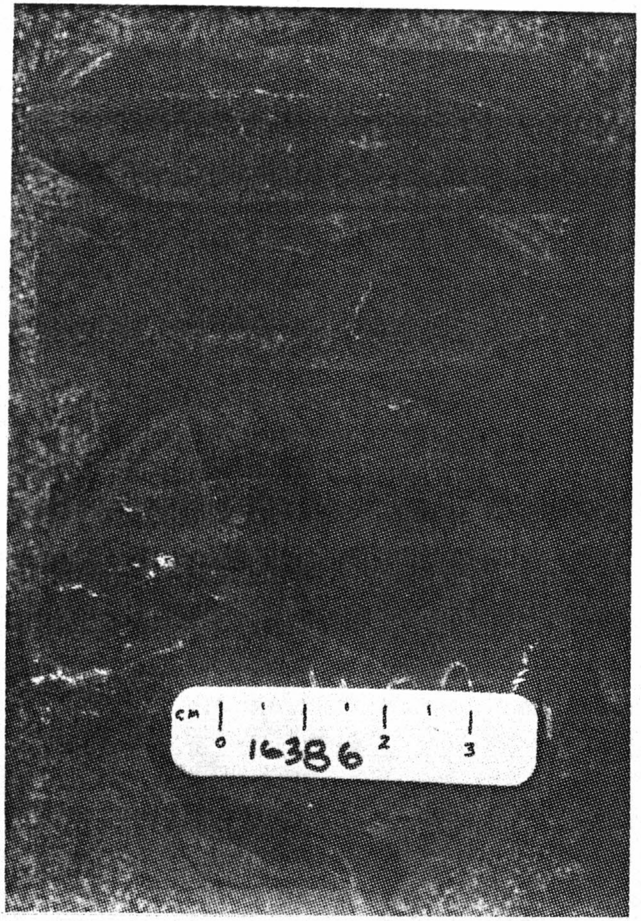
6. Interbedded white quartzose siltstone and gray siltstone.



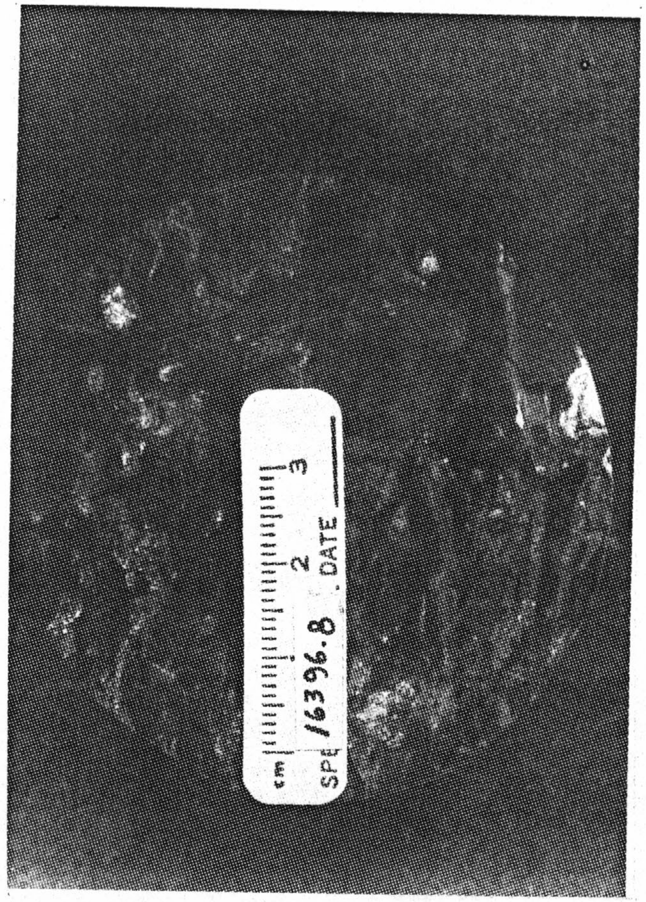
7. Ripple laminations in siltstone lithofacies.



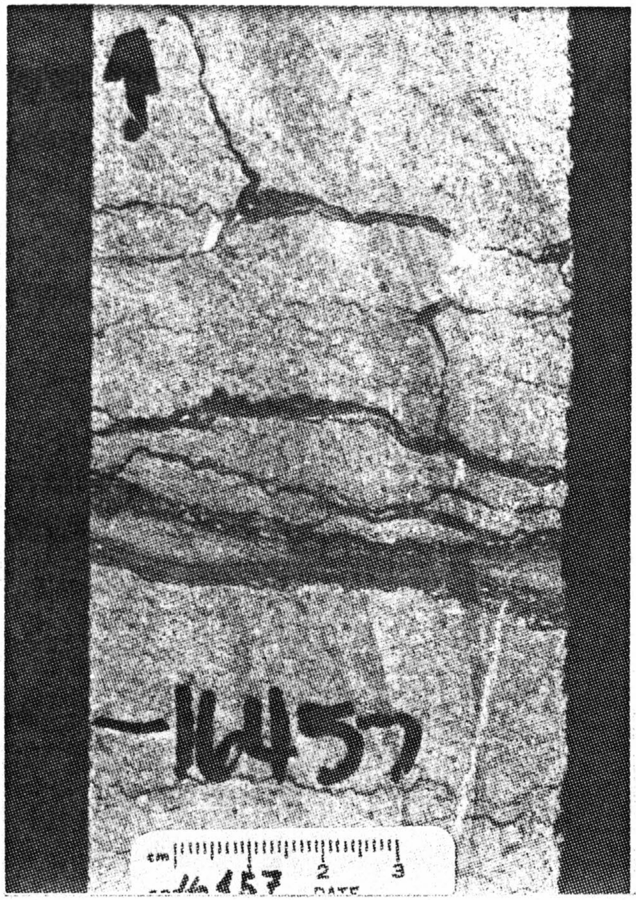
8. Combination of vertical and horizontal burrows in flaser unit in the siltstone lithofacies.



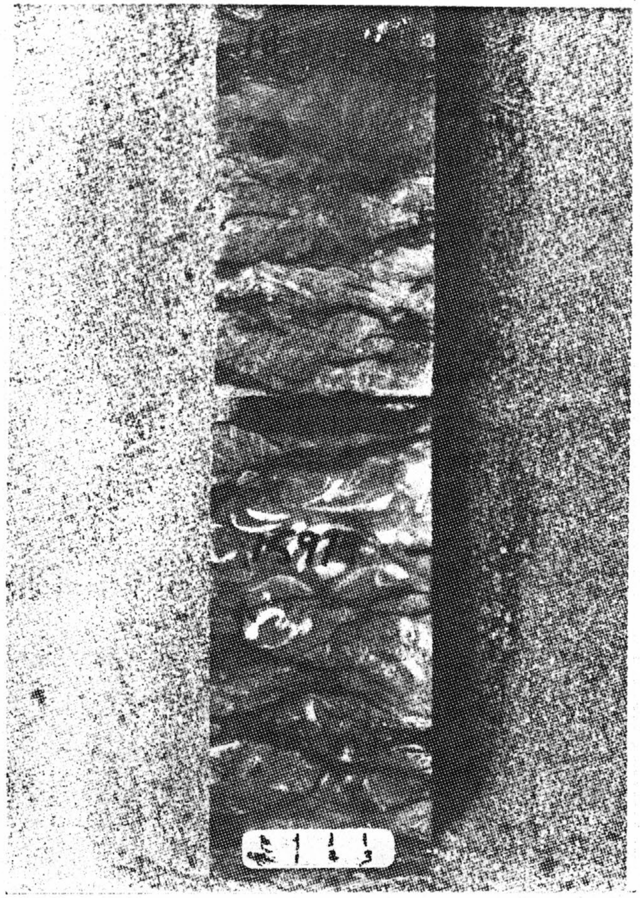
9. Dark-gray, waxy mudstone lithofacies.



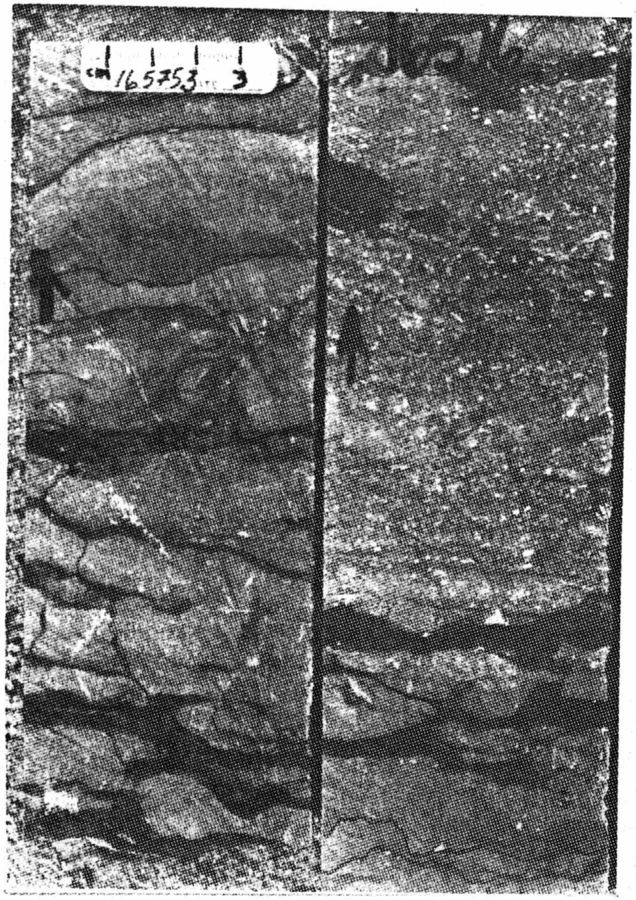
10. Vertical and horizontal burrows in mudstone lithofacies.



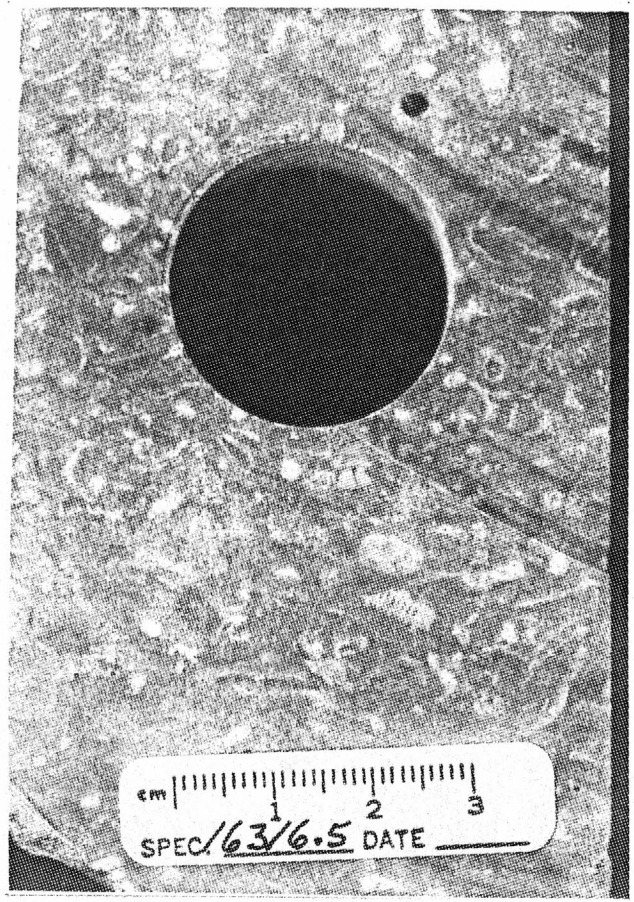
11. Light-gray dolomitic limestone (biosparite) lithofacies; interbedded with light-gray biomicrite.



12. Nodular bedding of limestone lithofacies with local concentrations of brachiopod fossils.



13. Dessication mudcracks in limestone lithofacies.



14. Brachiopod and crinoid fossil fragments in limestone lithofacies.