

THE AMERICAN UPPER ORDOVICIAN STANDARD. XIX. A MIDDLE AND UPPER ORDOVICIAN REFERENCE STANDARD FOR THE EASTERN CINCINNATI REGION¹

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ABSTRACT

A 1,200-foot core (designated CA-38) drilled by Cominco American, Inc., just east of Minerva, Mason County, Kentucky, provides an essentially complete section from near the top of the Fairview Formation (Upper Ordovician, Maysvillian) to the base of the Middle Ordovician High Bridge Group. The lowest 850 feet of the core penetrates a part of the Ordovician section that is not exposed in the eastern Cincinnati region, and the uppermost 350 feet provides a more nearly complete stratigraphic record than is exposed in a single surface section. Thus we suggest that core CA-38 be a primary reference standard for stratigraphic units in the eastern Cincinnati region. As a first step in establishing such a standard, we present for the uppermost 665 feet of the core a shale-percentage log, a clastic-ratio log, and a log showing the ranges and relative abundances of important conodont species. This portion of the core represents the stratigraphic interval above the base of the Lexington Limestone. Correlation and nomenclature of units in the uppermost 665 feet of core CA-38 is effected by comparing the logs with similar ones for important surface and subsurface sections elsewhere in the Cincinnati region.

INTRODUCTION

Bedrock exposures are numerous in the Cincinnati region of north-central Kentucky and adjacent parts of Ohio and Indiana, but thick well-exposed surface sections are few, and only a little information has been published about the distribution of stratigraphic units in the subsurface. For these reasons, more than ordinary interest attaches to long continuous records of the sort provided by the 1,200-foot core whose upper part we describe in this report.

The core to which we refer is a standard BX-core. It was recovered by Cominco American, Inc., in July 1970 from a hole drilled on the T. W. Richardson farm at a site 916 feet above sea level and about 0.35 mile east of Minerva, Mason County, Kentucky (fig. 1). The location of the core hole is especially significant because it is just 4.5 miles south-southeast of the type surface section of the Upper Ordovician Kope Formation (Weiss and Sweet, 1964) and some 9.5 miles northwest of a 350-foot exposure at Maysville, Kentucky (Carpenter and Ory, 1961). These exposures are important reference sections in the eastern Cincinnati region for rocks of early and mid-Cincinnatian (Edenian and Maysvillian) ages. In the Kope type section, however, the uppermost 90 feet of the Kope Formation is too poorly exposed to be measured and described in detail, and only a limited thickness of the subjacent Point Pleasant Formation is exposed. At Maysville the exposed section begins about 70 feet above the base of the Kope Formation and is continuous into rocks of early Richmondian age.

By means of the core section we describe here, it is possible to relate the type Kope section of subjacent stratigraphic units that are not exposed at all in the eastern part of the Cincinnati region. Furthermore, lithic bodies that have previously been misunderstood or have not been recognized in that area can be identified and correlated with rocks in exposed sections to the south and west. For these reasons, we propose that core CA-38 be regarded as a primary reference standard for Middle and Upper Ordovician stratigraphic units in the eastern part of the Cincinnati region.

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THE CORE LOGS

Core CA-38, which represents 1,213 feet of section, was drilled, boxed, and labeled in July 1970 by personnel of Cominco American, Inc. Shortly thereafter, all but a short segment at the base of the core was given to us for study by Cominco American and was brought to us by Dr. Arie Janssens of the Ohio Division of Geological Survey. The core is now stored permanently in the Micropaleontological Laboratory of the Department of Geology and Mineralogy at The Ohio State University.

Late in 1970 and early in 1971 core CA-38 was measured and sampled for conodonts by the junior authors of this report, and the uppermost 665 feet of it were described in a manner that has proved useful in discriminating lithic units elsewhere in the Cincinnati region (Weiss *et al.*, 1965). In general, the procedures we employed involved measuring and recording the thickness and general lithology

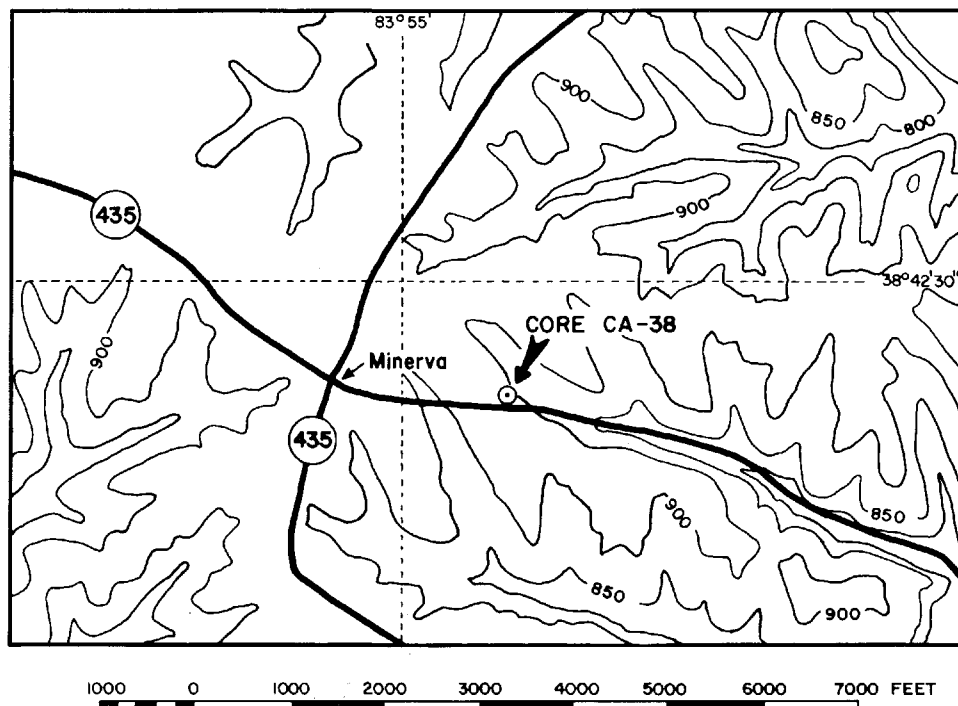


FIGURE 1. A portion of the Germantown, Kentucky, 7.5-minute quadrangle, simplified to show location of the site at which core CA-38 was drilled.

(shale or limestone) of every bed thicker than 0.01 foot and constructing from these data various types of logs that show vertical variations in bulk properties of the rock bodies represented. In figure 2 we present (1) a shale-percentage log, which is an unsmoothed record of shale thickness stated as a percentage of the total thickness of successive 3-foot intervals, and (2) a log of clastic ratio, which records the ratio of shale to limestone in successive 3-foot units, but which is smoothed over 9-foot intervals. Although it is "noisier," we prefer the shale-percentage log (fig. 2A) to the smoothed log of clastic ratio (fig. 2B) because it is easier to compute and shows minor, but significant, variations in lithic information more distinctly than does the smoothed log of clastic ratio. We present both, however, because much of the published information on rocks of the Point Pleasant, Kope, and Fairview Formations is given in smoothed clastic-ratio logs (Weiss

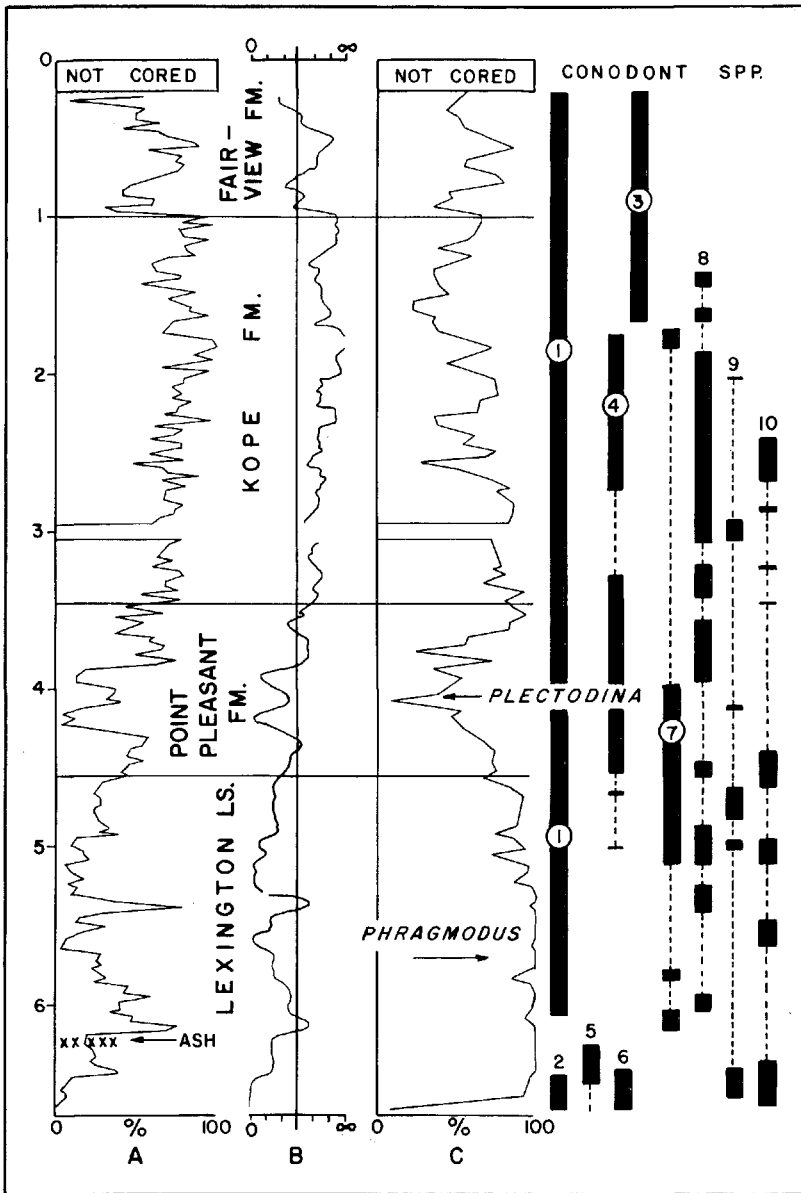


FIGURE 2. Logs of uppermost 665 feet of core CA-38 and vertical ranges of 11 conodont species. Log A depicts shale percentage, log B is a smoothed log of clastic ratio, log C charts vertical fluctuations in relative abundance of *Phragmodus undatus* with respect to two species of *Plectodina*. Black bars give ranges of (1) *Plectodina furcata* (Hinde), (2) *P. aculeata* (Stauffer), (3) *Oulodus oregonia velicuspis* (Pulse & Sweet), (4) *O. o. oregonia* (Branson, Mehl & Branson), (5) *Polyplacognathus ramosus* Stauffer, (6) "Fibrous" conodonts, (7) *Icriodella superba* Rhodes, (8) *Amorphognathus* spp., (9) *Aphelognathus abruptus* (Branson & Mehl), (10) *Panderodus gracilis* (Branson & Mehl). The numerals 0 through 6 along the left margin of log A scale 100-foot units measured from the top of the core.

and Sweet, 1964; Weiss *et al.*, 1965; Osborne, 1968) that cannot be converted to simpler logs of shale percentage without access to the original data. In our preference for shale-percentage logs as a means of displaying gross lithic characters we are in agreement with Ford (1967), whose summary of the bulk properties of Upper Ordovician rocks in southwestern Hamilton County, Ohio, has been very useful to us in interpreting some parts of the section preserved in core CA-38.

As we measured and described core CA-38, we also collected 300- to 500-gram limestone samples at approximately 5-foot intervals to a level in the core that was 663 feet below the ground surface. The base of our sampled section is the contact between the Lexington Limestone and the underlying Tyrone Limestone (fig. 2). The section from 665 feet to the bottom of the core (1,213 feet) was sampled in a similar manner by Dr. Robert B. Votaw (now of Indiana University Northwest), who will present his observations elsewhere.

The limestone samples we collected and those retrieved by Dr. Votaw were digested in 15-percent acetic acid, and conodont elements were sorted from the insoluble residues onto micropaleontological slides. These slides are filed in the permanent collections of the Micropaleontological Laboratory of the Department of Geology and Mineralogy, The Ohio State University. The slides have the catalog designation 70ZA.

From the 125 post-Tyrone samples processed, we recovered about 46,000 identifiable conodont elements, which are assignable to 21 species of 16 genera. We indicate the ranges of 11 species in figure 2 (log C and bars to the right of it). Sample-by-sample tabulations are on file with the collections. Representatives of the conodont species *Phragmodus undatus* Branson and Mehl, *Plectodina aculeata* (Stauffer), and *Plectodina furcata* (Hinde) dominate our collections. At least a few specimens of *Phragmodus undatus* occur in every sample from the base of the Lexington Limestone upward, and *Plectodina furcata* is represented in all but 10 samples above the 608-foot level in core CA-38. *Plectodina aculeata*, the precursor of *P. furcata*, is confined to the interval below 645 feet. These three species are characteristic members of an Ordovician conodont fauna that was widely distributed in the North American Midcontinent (Sweet *et al.*, 1959; numerous subsequent references cited in Bergström and Sweet, 1966). Features of the vertical and lateral distribution of this fauna have been very useful in effecting detailed correlations of Middle and Upper Ordovician rocks in the Cincinnati region (Bergström and Sweet, 1966; Sweet and Bergström, 1971). To illustrate this, in log C of figure 2 we present a record of vertical fluctuations in the relative abundance of *Phragmodus* and *Plectodina* in core CA-38, and in figure 3 we demonstrate the utility of this log in supporting correlations between stratigraphic units penetrated by the core and those exposed elsewhere in the Cincinnati region.

STRATIGRAPHY

In table 1 we summarize our conclusions as to the stratigraphic identity of rocks units penetrated by core CA-38. In the table we provide bulk parameters for each unit. The positions of formational contacts are shown in figure 2.

Grant Lake Limestone

Drilling of the hole from which core CA-58 was recovered began 916 feet above sea level in the Grant Lake Limestone (Upper Ordovician, Maysvillian), whose lower contact is mapped at an altitude of about 910 feet immediately east of the drilling site (Outerbridge, 1971). The uppermost 20 feet of the drill hole was not cored, however, so the section recorded in figure 2 begins about 896 feet above sea level at a horizon in the upper part of the Fairview Formation about 14 feet below the base of the overlying Grant Lake Limestone.

TABLE 1
Formation contacts and summary of bulk lithic characters

Depth in core (ft)	Elevation above sea level (ft)	Formation	Thick- ness (ft)	Clastic ratio		Shale content (%)		Bedding index	
				Range	Mean	Range	Mean	Range	Mean
0-6	916-910	GRANT LAKE LIMESTONE	6	(Not cored)					
(6-98)	(910-818)	FAIRVIEW FORMATION	(92)	0.1-3.2	1.67	9-89	54	100-767	452
6-20	910-896	Upper Fairview	14	(Not cored)					
20-47	896-869	Upper Fairview	27	0.1-1.8	0.82	9-64	43	100-767	436
47-56	869-860	Miamitown Shale	9	2.0-8.1	3.16	67-89	80	200-467	312
56-98	860-818	Lower Fairview	42	0.6-3.2	1.41	37-77	54	333-700	478
(98-344)	(818-572)	KOPE FORMATION	246	0.8-	2.80	45-100	74	67-800	371
98-245	818-671	Upper three-fifths	147	1.0-	3.22	50-100	77	67-733	325
245-344	671-572	Lower two-fifths	99	0.8-8.1	2.06	45-89	68	133-800	445
(344-455)	(572-461)	POINT PLEASANT FORMATION	111	0.0-2.3	0.70	0-76	41	33-933	429
344-386	572-530	Upper Point Pleasant	42	0.5-2.3	1.21	34-76	55	233-700	445
386-428	530-488	Middle Point Pleasant	42	0.0-0.7	0.26	0-41	21	33-933	369
428-455	488-461	Lower Point Pleasant	27	0.7-1.3	0.92	40-57	48	300-700	496
(455-665)	(461-251)	LEXINGTON LIMESTONE	210	0.0-3.5	0.31	0-78	24	267-1133	618
455-530	461-386	Upper Grier Member	75	.05-.63	0.26	5-39	21	267-1133	753
530-542	386-374	Macedonia Bed	12	.34-3.5	0.75	25-78	43	433-933	633
542-587	374-329	Lower Grier Member	45	.03-.43	0.22	3-30	18	267-933	691
587-644	329-272	?Logana Member	57	0.2-2.9	0.74	17-75	37	333-700	507
644-665	272-251	Curdsville Member	21	0.0-0.1	0.04	0-9	4	167-400	262

Fairview Formation

The uppermost 78 feet of core CA-38 is identified as part of the Fairview Formation (Upper Ordovician, Maysvillian), which is a widespread body of interbedded limestone and shale, mudstone, and siltstone that lies regionally above dominantly shaly rocks of the Kope Formation (Weiss and Sweet, 1964) and below rubbly nodular limestones that contain abundant *Platystrophia* and *Hebertella* and are variously identified as Bellevue Limestone (Ford, 1967; Osborne, 1968) or Grant Lake Limestone (Peck, 1966; Outerbridge, 1971).

In core CA-38 the section of rock we identify as Fairview is clearly divisible into three parts, the bulk qualities of which are listed in table 1. The uppermost and lowest parts are similar and, although somewhat shalier and more thinly bedded than typical Fairview in the city of Cincinnati (Ford, 1967), they are more like type Fairview than is the 9-foot-thick middle part. Bulk characters of the middle part are similar to those of the Miamitown Shale of southwestern Ohio (Ford, 1967; Osborne, 1968), and a regional synthesis suggests that these mid-Fairview strata are part of the body of the Miamitown Shale. Thus we regard the Miamitown Shale as a member of the Fairview Formation and equate the 9-foot midsection of the Fairview in core CA-38 with it. It is of interest to note that the Miamitown occurs at the top of the Fairview in southwestern Ohio and is succeeded directly there by rocks assigned to the Bellevue (Grant Lake) Limestone by Ford (1967) and by Osborne (1968). In the eastern Cincinnati region, however, some 41 feet of Fairview separate the Miamitown from the Grant Lake.

In the section at Maysville, Kentucky (Carpenter and Ory, 1961; Weiss and Sweet, 1964), and in the Germantown, Kentucky, quadrangle (Outerbridge, 1971) a set of closely spaced limestone beds with abundant *Strophomena planoconvexa* marks the basal few feet of the Fairview. A series of thick limestone beds between 93 and 97 feet in core CA-38 is probably equivalent to this zone, but we have not identified *S. planoconvexa* in these beds.

Kope Formation

The 246 feet of dominantly shaly strata just beneath the Fairview Formation in core CA-38 are clearly identifiable with the Kope Formation, which is typified by surface exposures in Kope Hollow near Levanna, Ohio (Weiss and Sweet, 1964). These exposures are just 4.5 miles north-northeast of the site at which core CA-38 was drilled. Compared with the type Kope, rocks herein identified with that formation are not as shaly and are somewhat more thinly bedded (mean clastic ratio 2.5-3.8; mean bedding index 300-230). The differences may be real, but we suspect they are more probably a result of the fact that very thin limestone beds are readily distinguished in the core section, but are difficult to see and measure in weathered surface exposures. That is, the figures given in table 1 for Kope clastic ratio, shale content, and bedding index may well be a more accurate statement of the bulk properties of that formation in its type area than were the values derived from surface sections by Weiss and Sweet (1964).

In core CA-38 the base of the Kope Formation is 344 feet below the top of the borehole, or approximately 572 feet above sea level. This base corresponds almost exactly to the base at the type section (Weiss and Sweet, 1964). In the northeast corner of the Germantown, Kentucky, quadrangle, however, Outerbridge (1971) has mapped the Kope base at about 530 feet above sea level. The discrepancy in basal elevations suggests either that Outerbridge mapped as basal Kope the 42 feet of very shaly sub-Kope strata here assigned to the upper part of the Point Pleasant Formation or that this interval becomes so much shalier in the 3.2 miles that separate surface exposures from the site at which core CA-38 was drilled that upper Point Pleasant strata have merged with the Kope Formation. Our first suggestion is the more likely one because the stratigraphic summary on the Germantown, Kentucky, quadrangle indicates that Outerbridge (1971) employed limits of "shaliness" (60-70 percent) that differ from those (67-100 percent) mentioned by Weiss and Sweet (1964) in the original definition of the Kope Formation.

Point Pleasant Formation

The 111 feet of dominantly calcareous rocks below the Kope Formation in core CA-38 form a distinctive stratigraphic unit that is developed regionally in various lithofacies and is thus one of the more troublesome entities in the Ordovician section of the Cincinnati region. This interval includes the lateral equivalents of the sub-Kope section at North Point Pleasant, Ohio. In figure 3 we indicate our correlation of this interval with the supra-Grier pre-Clays Ferry portion of the Lexington Limestone type section near Frankfort, Kentucky. No single name is available for the entire unit, but it has most commonly been termed "Cynthiana" (Nosow and McFarlan, 1960; Weiss *et al.*, 1965). Black, Cressman, and MacQuown (1965) include this unit in the upper part of the Lexington Limestone, but Outerbridge (1971) and Luft (1972) have mapped the same strata as Point Pleasant Formation, and Sweet and Bergström (1971) used this name because it is certainly the oldest one available (Orton, 1873) for any of the strata included.

The Point Pleasant Formation apparently consists of three westward-thinning tongues of calcareous strata separated by shalier eastward-thinning tongues. Depending on the situation of type exposures with respect to the distal or proximal extremities of these tongues, the names River Quarry, Point Pleasant, Nicholas, Woodburn, Tanglewood, or Devils Hollow have been applied to lithic or faunally defined units in the calcareous tongues, whereas the terms Brannon, Millersburg, and probably Rogers Gap and Greendale have been used for parts of the shalier tongues. Although a classification of lithic units has been proposed for the central part of the Cincinnati region (Black, Cressman, and MacQuown, 1965) and identification of some of those units within the Point Pleasant Formation of core CA-38 is suggested in figure 3, we indicate only an informal division of the Point Pleasant in table 1. In figure 3, however, we do suggest that rocks between the base of the Brannon and the base of the Clays Ferry Formation at Frankfort and Clays

Ferry, Kentucky, form part of the rock body for which Outerbridge (1971), Luft (1972), and we are using the name Point Pleasant Formation. Most of the Point Pleasant Formation, as thus delimited, is of Late Ordovician (Cincinnatian, Edenian) age, however, not dominantly Middle Ordovician as indicated by Outerbridge and Luft.

In core CA-38 the Point Pleasant is readily divisible into three major parts, for which we give information on bulk characters in table 1. It may be noted here that Point Pleasant strata are invariably more calcareous than the Kope or Clays Ferry rocks that overlie them and are appreciably shalier than the Lexington Limestone beneath. Point Pleasant strata are also more thickly bedded than Lexington strata and somewhat more thinly bedded than the superjacent Kope.

Most of the rock to which Orton (1873) applied the name "Point Pleasant Bed" is no longer exposed in the type area. Thus we propose that core CA-38 be regarded as the principal reference section for this formation.

Lexington Limestone

Beneath the Point Pleasant Formation in core CA-38 are 210 feet of thin-bedded carbonates and subordinate shales that appear to correlate almost exactly with the Curdsville, Logana, and Grier Members of the Lexington Limestone at its type section near Frankfort, Kentucky (fig. 3). The uppermost 132 feet of the core CA-38 Lexington section is clearly Grier, and even the distinctive Macedonia

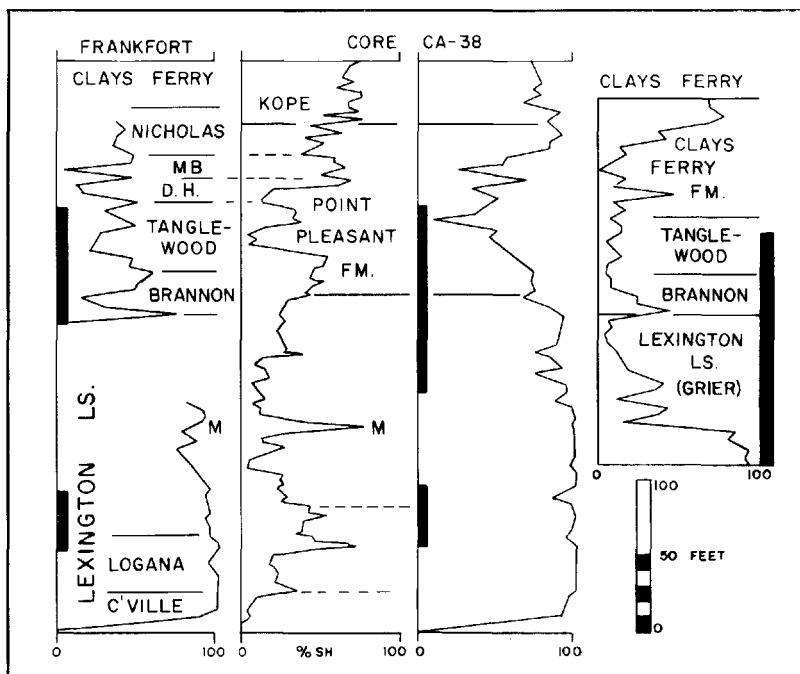


FIGURE 3. Correlation of the Lexington Limestone and Point Pleasant Formation of core CA-38 with (1) type section of Lexington Limestone, south of Frankfort, Kentucky (log on left), and (2) incomplete section of Lexington Limestone and Clays Ferry Formation at Clays Ferry, Kentucky (log on right). Frankfort and Clays Ferry log depict relative abundance of *Phragmodus undatus* with respect to *Plectodina*, as does right-hand CA-38 log; left-hand CA-38 log is a shale-percentage log. Vertical black bars indicate ranges of *Icriodella superba* Rhodes in the three sections. "M" indicates Macedonia Bed, "D.H." indicates Devils Hollow Member, and "MB" indicates Millersburg Member.

Bed (Black, Cressman, and MacQuown, 1965) within the Grier Member is readily distinguishable (fig. 3). The 57-foot interval we identify tentatively with the Logana Member (table 1, fig. 3) is appreciably thicker than the Logana in the central Cincinnati region. This may indicate that Logana strata in core CA-38 occupy a proximal position in a southward- or southeastward-thinning shaly tongue, which disappears into the Grier Member in southern Jessamine County, Kentucky (Black, Cressman, and MacQuown, 1965). We should note also that two thin closely spaced beds of volcanic ash occur near the middle of the Logana in core CA-38 (621 and 622 feet below the top of the core). No such beds are mentioned as features of the Logana by Black, Cressman, and MacQuown (1965), but Templeton and Willman (1963) show a bentonite in the Logana in a section just south of Frankfort, Kentucky.

The base of the Lexington Limestone in core CA-38 is clearly marked by the abrupt appearance at 665 feet (251 feet above sea level) of thick-bedded light-gray calcilitites typical of the Tyrone Limestone.

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