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Conodonts, Conodont Biostratigraphy and Correlation of the Moffett Road Section (Middle and Upper Ordovician), Kenton County, Kentucky

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Abstract.—The nearly 43,000 conodont-elements isolated from 286 samples collected at approximately 1.8-foot intervals from the 341-foot Moffett Road section in Kenton County, Kentucky, represent 20 species of 17 genera. Their vertical distribution and relative abundance indicate that the lower 54 feet of strata exposed in the section are of Middle Ordovician (Shermanian) age; that the succeeding 257-265 feet of Kope Formation are of Late Ordovician (Edenian and early Maysvillian) age; and that the uppermost 26-30.4 feet of the section, identified as Fairview Formation, are of Late Ordovician (Maysvillian) age. If the basal contact of the Kope Formation in the Moffett Road section were designated the stratotype of the base of the Edenian Stage (and Cincinnatian Series), a thickness of 239 feet would be established for the Edenian Stage in its stratotypical area, and regional correlations indicate that that level would correspond very closely to the top of the stratotypical Shermanian Stage in northern New York.

Introduction

Conodonts are abundant in the Middle and Late Ordovician rocks of southwest Ohio and adjacent parts of Kentucky and Indiana (the Cincinnati Region of fig. 1), and the well-documented distribution of about 463,000 identified specimens in samples from 54 localities now serves as the principal basis for biostratigraphic characterization and correlation of those strata (Sweet, 1979a). Impetus for such detailed study derives primarily from the fact that the richly fossiliferous Upper Ordovician rocks of the Cincinnati Region include the stratotypes of the Cincinnatian Series and of three of the four stages (Edenian, Maysvillian, Richmondian, Gamachian) into which it is customarily divided in North America (Ross et al., 1982). It is thus of more than ordinary importance that the sequence and distribution of various fossil groups be documented in detail in those rocks.

This report documents the distribution of an additional 42,827 conodont specimens, assigned to 20 species of 17 genera, in a 341-ft exposure of Middle and Upper Ordovician rocks along Kentucky Highway 2042 (Moffett Road), 0.5 miles west of Kenton, in the De Mossville 7.5-minute quadrangle, Kenton County, Kentucky (Fig. 2). That exposure, the Moffett Road section of this report, was measured and described, and the 286 samples from which conodonts were derived were collected in 1969 by J. Pojeta, Jr., R. J. Ross, Jr., and O. J. Karklins, of the U. S. Geological Survey, and W. T. Dean, of the Geological Survey of Canada. Samples were subsequently processed by U. S. Geological Survey personnel in Washington, DC, and 400 microslides bearing carefully sorted collections of conodonts were sent to the author for study in March, 1982. The writer's contribution has thus been restricted to identification and tabulation of the specimens, and to biostratigraphic interpretation of the sequence of conodont species recorded in the Moffett Road section. Other components of the invertebrate fauna have been assigned to various specialists for study, and a report on the bryozoans has already been completed (Karklins, 1983).

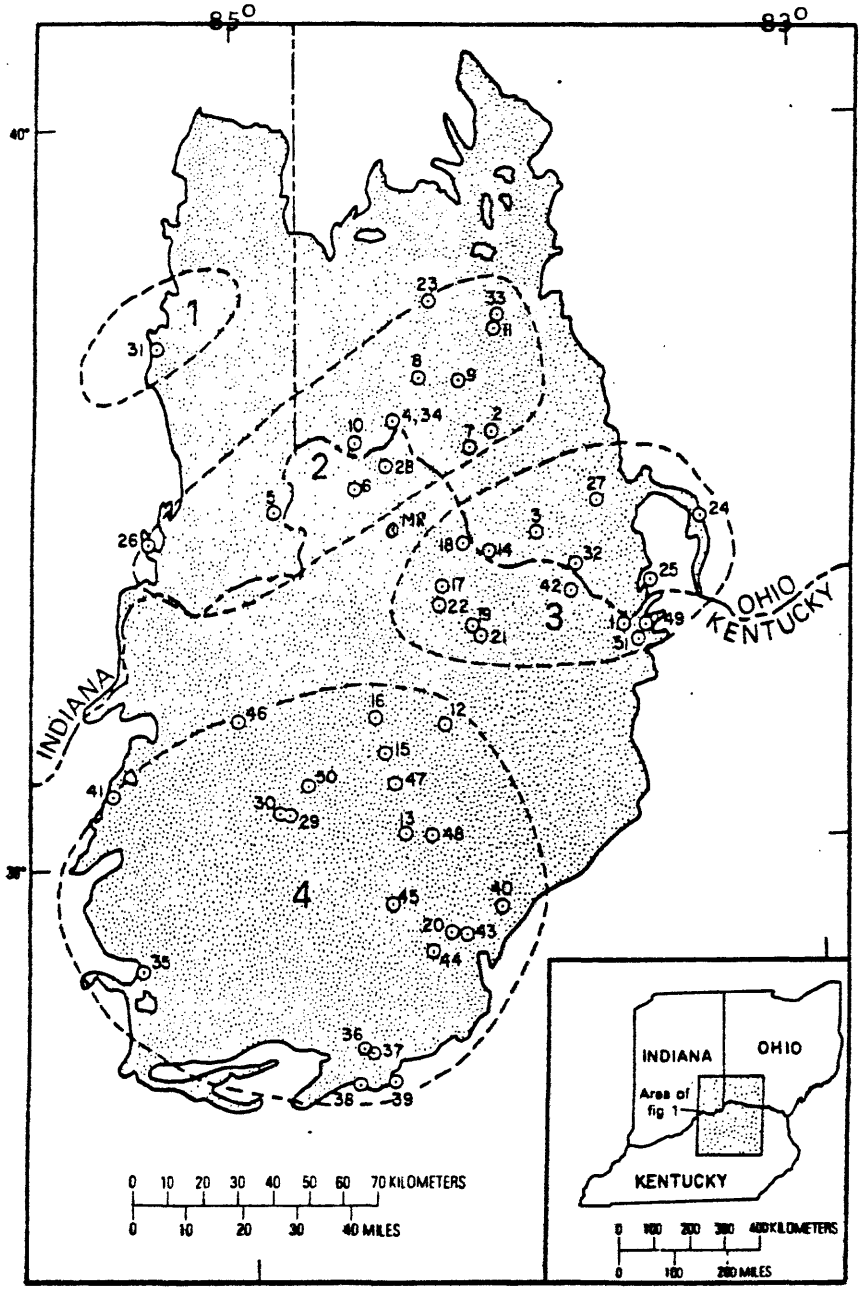

FIGURE 1.--Index map of the Cincinnati Region (patterned) showing location of sections (numbered and lettered, circled dots) from which post-Tyrone Ordovician conodonts have been collected. Moffett Road section, MR, is situated slightly north of center of Cincinnati Region; location of other sections is explained in Sweet (1979a). From Sweet (1979a).

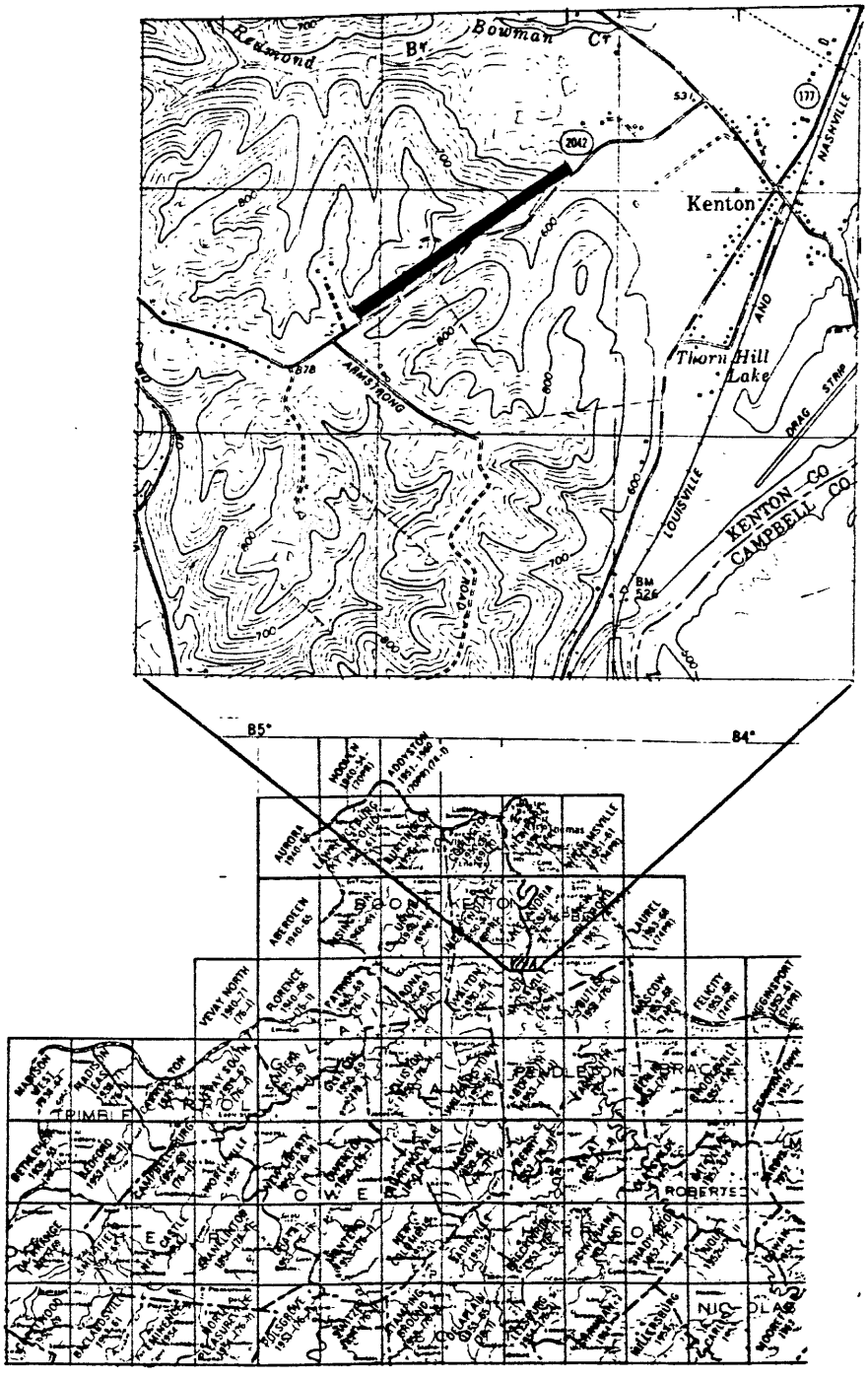

FIGURE 2.--Location of Moffett Road section (black bar, upper map) in the DeMossville 7.5-min. quadrangle, Kenton County, Kentucky. Squares in upper map are 1 km (0.62 mi) on a side.

The Moffett Road Section

The section from which the samples considered in this report were obtained is exposed in an unnamed creek valley and along the adjacent margins of Kentucky Highway 2042 (Moffett Road) about 0.5 miles west of Kenton, Kenton County, Kentucky. On the De Mossville, Kentucky, 7.5-minute quadrangle the base of the Moffett Road section is 118.5 mm east and 547 mm north of the lower left, or southwest corner, of the map. The De Mossville quadrangle has been mapped geologically by Luft (1970).

At the time samples were collected from the Moffett Road section, 341.4 ft of strata were exposed. The lower 54 ft were assigned by the samplers to the Point Pleasant Tongue of the Clays Ferry Formation; the succeeding 257 ft to the Kope Formation; and the upper 30.4 ft to the Fairview Formation. Karklins (1983), however, reports a thickness of about 265 ft for the Kope and 26 ft for the Fairview in the Moffett Road section. Reasons for the disparity between figures for Kope and Fairview thicknesses in copies of the original field notes supplied the writer and in Karklins' (1983) report are not apparent. Those differences can not be reconciled because major parts of the Moffett Road section are now covered or very poorly exposed. However, agreement on thickness of the Kope Formation exposed in th Moffett Road section would be important only if the Kope Formation exposed in that section were to be established as a stratotype for the Edenian Stage, as Pojeta (1981) has suggested. That is, if Pojeta's suggestion were to be adopted, it would be important to determine the thickness of the Kope Formation in the Moffett Road section very accurately and also to determine that the top of the formation in that section corresponds to the base of the superjacent Maysvillian Stage in its stratotypical section along Clifton Avenue in the City of Cincinnati, Ohio.

Conodonts

Conodonts were obtained from 256 samples, spaced somewhat erratically through the Moffett Road section, but averaging 1.8 ft apart. No information is available to the author concerning the weight of rock processed for conodonts.

The 42,827 specimens identified are referable to the 20 conodont species listed and named in table 1, and the frequencies of occurrence and local ranges of those species are given on a sample-by-sample basis in appendix A. All of the conodonts from the Moffett Road section are referable to well-known Middle and Late Ordovician taxa, hence none is discussed systematically. Table 1, however, provides references to recent descriptions and illustrations of the taxa identified.

Conodonts from the Moffett Road section, like those from Ordovician rocks at other localities in the Cincinnati Region, have a color-alteration index (Epstein, Epstein & Harris, 1977) of 1.0 and the majority are very well preserved. As indicated in appendix A, frequencies are generally lower in shale samples than in limestone samples, but quantitative comparisons would not be significant in the absence of information on the weight of sample processed for conodonts.

In table 1 and appendix A, the range of Amorphognathus superbus is divided into two segments, one between the base and 237 ft above the base of the section in which the holodontiform elements characteristic of the species have been

Table 1.--Conodont species represented in the Moffett Road section; their local and regional stratigraphic ranges; and references to sources in which they have been fully described and illustrated.

Species No.	Name	Range (in ft. above section base) Moffett Road	Cincinnati Region	Reference*
4	Amorphognathus superbus	0-237 ?250.6-338.4	772-1145	5
10	Aphelognathus politus	26.6-38.6	708-1551	6
22	Belodina confluens	50.3-237.0	845-1176	6
25	"Bryantodina" abrupta	111.0-199.5	567-1093	2
26	"Bryantodina" staufferi	1.1	646-935	2
59	Dapsilodus mutatus	4.5-177.5	641-1180	2
36	Drepanoistodus suberectus	1.1-341.4	88-1551	2
40	Icriodella superba	3.5-212.3	646-1328	2
OV	"Oistodus" venustus	13.3-154.5	?	2
48	Oulodus oregonia subundulata	0.5-184.5	700-1020	6
50	Oulodus velicuspis	210.9-341.4	995-1258	6
55	Panderodus gracilis	59.8-324.4	118-1542	2
56	Panderodus panderi	141.6-169.5	635-1115	3
60	Periodon grandis	34.8-169.5	650-976	6
64	Phragmodus undatus	0.5-341.4	567-1516	6
69	Plectodina tenuis	0.5-341.4	665-1546	6
82	Protopanderodus liripipus	0.5-212.3	665-1306	1
85	Pseudobelodina dispansa	66.8-147.1	?	6
98	Rhodesognathus elegans	4.5-319.9	646-1226	5
102	Staufferella falcata	2.1-341.4	703-1202	4

*References:

1. Kennedy, Barnes and Uyeno, 1979.

2. Bergstrom and Sweet, 1966.

3. Sweet, 1979b.

4. Sweet, Thompson and Satterfield, 1975.

5. Ziegler, 1977.

6. Ziegler, 1981.

recovered from a large number of samples, and another 250.6 to 338.4 ft above the base of the section in which elements of Amorphognathus occur in limited numbers but holodontiform elements have not been identified. Because holodontiform elements have not been recovered from the upper range-segment, positive identification of the species can not be made. However, it is likely that A. superbus is the species represented in the upper segment, for upward adjustment of the range-top numbered "4" in figure 3 of this report would place it almost exactly on the line of correlation and indicate that the highest occurrence of Amorphognathus in the Moffett Road section very nearly coincides with the highest known occurrence of A. superbus in the Cincinnati Region.

The conodont species labeled "OV" ("Oistodus" venustus) in table 1 and appendix A was included by Sweet (1979a) as a component of the skeletal apparatus of a multielement species named Paroistodus (=Dapsilodus) mutatus in that report. Recent studies, as yet unpublished, indicate that the skeletal apparatus of Dapsilodus mutatus does not include an oistodontiform element; hence identity of "Oistodus" venustus in multielement taxonomy is uncertain. We do not list its regional range, for that would require a complete canvass of our records and such an exercise would not add appreciably to the information summarized in this report.

No Cincinnati-Region range for Pseudobelodina dispansa is given in table 1 because that species was regarded as a junior subjective synonym of Belodina compressa until 1979 when Sweet (1979b) made an extensive revision of this group of conodonts. Establishment of the Cincinnati-Region range of P. dispansa will require re-examination of all Cincinnati-Region collections, a task that is beyond the scope of this report.

Correlations

Because the vertical ranges of conodont and most other invertebrate species are long relative to stratal thickness in the Middle and Upper Ordovician rocks of the Cincinnati Region, detailed correlations between even closely spaced sections are difficult by conventional biostratigraphic means. A combination of the now well-known techniques of graphic correlation (Shaw, 1964; Miller, 1977; Sweet, 1979b; Sweet, 1982; Amsden and Sweet, 1983; Sweet, 1983) and relative-abundance analysis (Sweet, Bergstrom and Rust, 1965; Sweet, 1979a) has proved highly successful, however, and those techniques are used here to effect correlation of rocks sampled in the Moffett Road section and Ordovician strata elsewhere in the Cincinnati Region.

Information on the vertical ranges of 47 conodont species has been used by the author to effect a closely controlled graphic correlation of Middle and Late Ordovician rocks at 34 localities in the Cincinnati Region. A thorough discussion and description of that exercise has not yet been published, but the resultant composite standard section is illustrated in a summary report now in press (Sweet, 1983), and pertinent values from it are listed in a Range column headed "Cincinnati Region" in table 1. Those values, which represent the total known composite stratigraphic ranges in the Cincinnati Region of the conodont species named in table 1, are stated in feet above the base of the Middle Ordovician High Bridge Group in a standard reference section, which is a core taken near Minerva, Kentucky (Sweet, Harper and Zlatkin, 1974).

In figure 3, conodont range-data from the Moffett Road section are plotted (on the Y axis) against conodont range-data from the Cincinnati Region composite

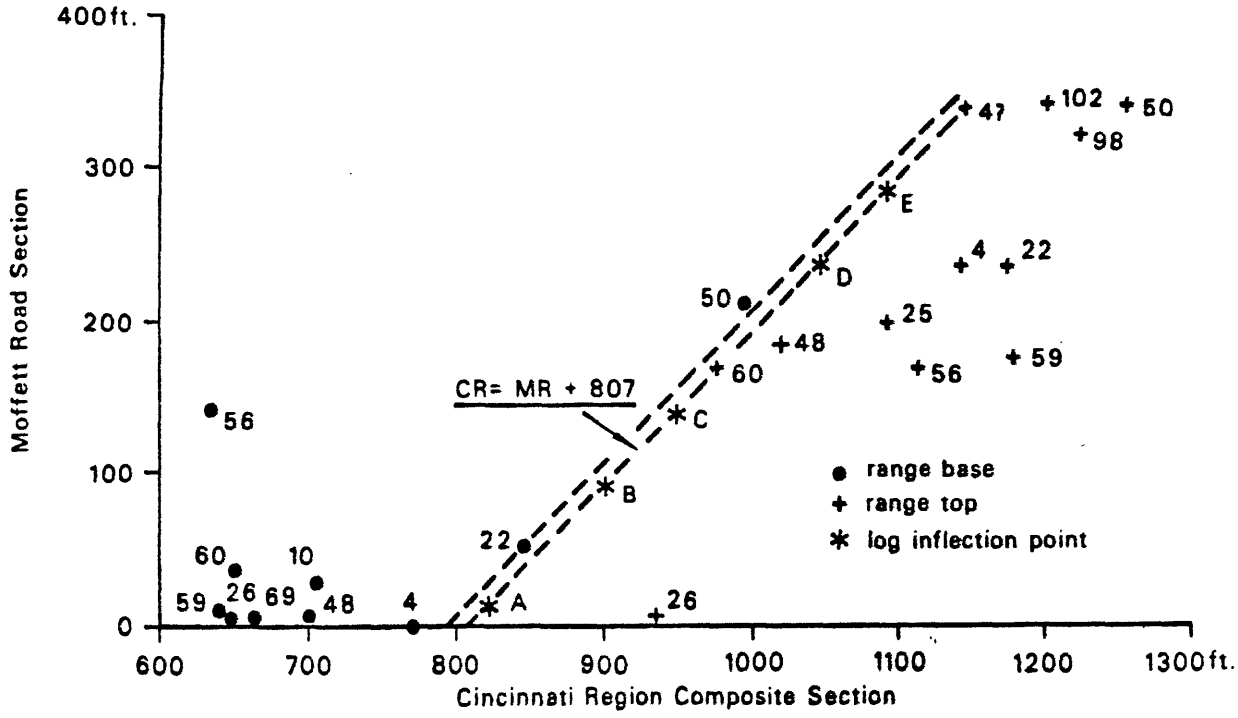

FIGURE 3.--Graphic correlation of Moffett Road and Cincinnati Region composite sections. Numbers near dots and crosses are those of the conodont species listed in table 1. Parallel dashed lines through B22 and T60 bracket position of the line of correlation from graphic analysis. Numbered stars, which indicate positions of log inflection points from figure 4, define a line that is parallel to the dashed one through T60 and only slightly to the right of it. The equation shown is for the dashed line through T60, which is regarded as the best expression of correlation between the two sections.

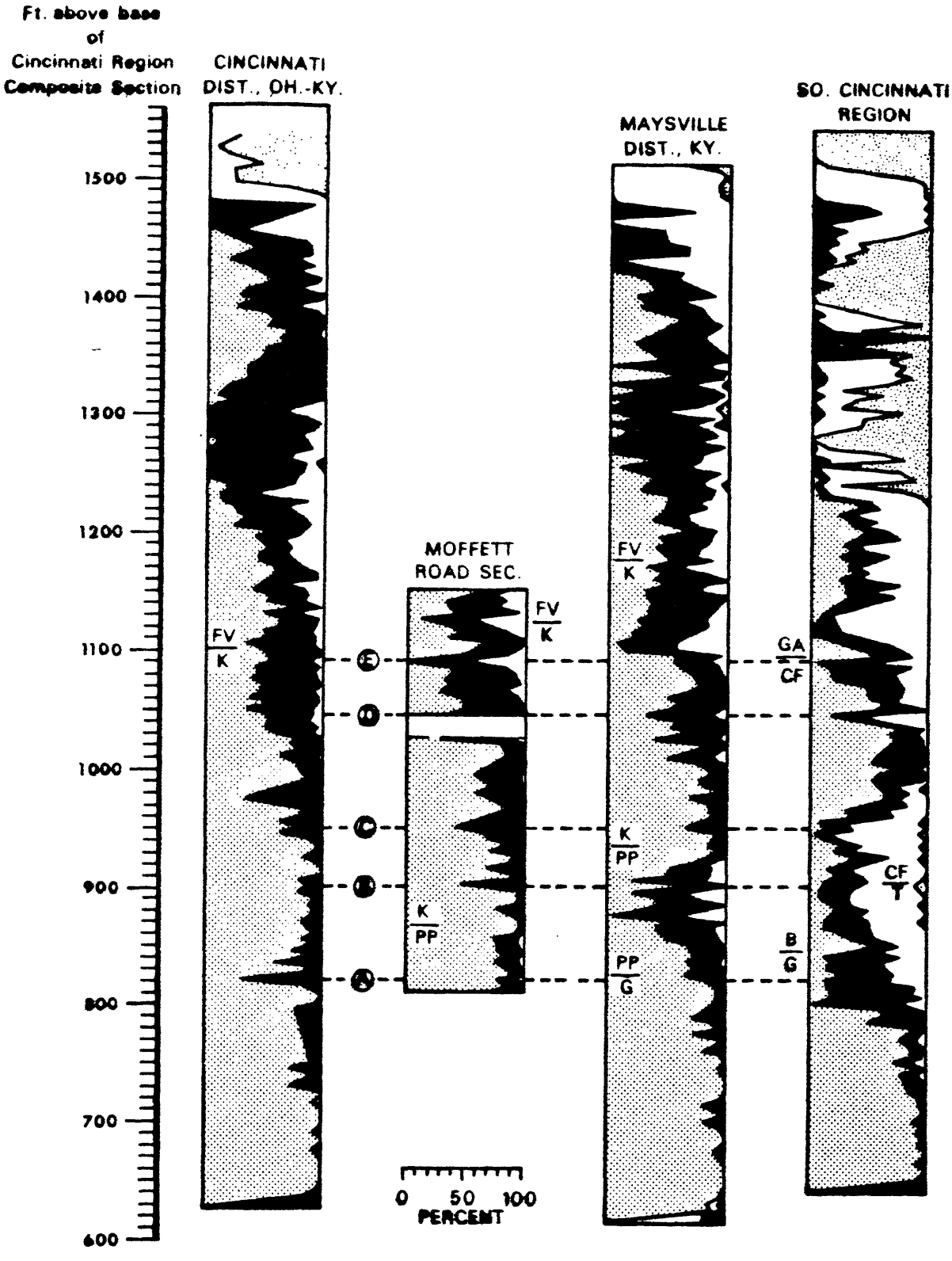

FIGURE 4.--Composite logs showing the relative abundance of Phragmodus undatus (coarse dots), Plectodina (black), Aphelognathus and Oulodus (white), and Rhipidognathus (fine dots) in the Moffett Road section and in three of the four districts of the Cincinnati Region enclosed in dashed lines in figure 1. Lettered horizontal lines join significant inflection points in logs, which are used in figure 3 to evaluate the results of graphic correlation.

B = Brannon Member of Lexington Limestone; CF = Clays Ferry Formation; G = Grier Member of Lexington Limestone; GA = Garrard Siltstone; FV = Fairview Formation; K = Kope Formation; PP = Point Pleasant Tongue of Clays Ferry Formation (or Point Pleasant Formation); T = Tanglewood Member of Lexington Limestone. FV/K contact in log on left is base of stratotype Maysvillian Stage; K/PP contact in Moffett Road log is proposed as base of stratotype Edenian Stage (and Cincinnatian Series).

standard section (on the X axis). The plotted array is typical of those for Cincinnati-Region sections, in which conodont species commonly have very long stratigraphic ranges. However, because rock-accumulation rates were evidently quite uniform from place to place in the Cincinnati Region during the Middle and Late Ordovician (Sweet, 1979a), the X-intercepts of parallel lines with slopes of 1 passed through the plotted range-base of species 22 (Belodina confluens) and the plotted range-top of species 60 (Periodon grandis) suggest that the base of the Moffett Road section is likely to be between 795 and 807 ft above the base of the Cincinnati Region composite section.

In figure 4, a conodont relative-abundance log of the Moffett Road section is compared with composite logs for post-Tyrone strata in three of the four major facies belts in the Cincinnati Region identified by Sweet (1979a) and shown by dashed circles in figure 1. The base of the Moffett Road log is set at the 810-ft level because that placement results in maximum log-pattern congruence and permits identification in the Moffett Road log of the levels of at least five inflection points that can be traced across the Cincinnati Region and apparently represent basinwide events. Those points are lettered A through E in figure 4 and their positions above the bases of the Moffett Road and Cincinnati Region composite sections are given in table 2.

Table 2.—Positions of relative-abundance log inflection points in feet above the base of the Moffett Road and Cincinnati Region composite standard sections.

Inflection Point	Moffett Rd. Sec.	Comp. Standard Sec.
A	10	820
B	90	900
C	140	950
D	235	1045
E	280	1090

In figure 3, inflection points A through E have been added to the graphic array. Because a straight line connecting inflection points would very nearly intersect the plotted range-top of species 60 (Periodon grandis), it is concluded that the chronostratigraphic relations between the Moffett Road and Cincinnati Region composite sections are best expressed by the position and slope of the dashed line drawn through T60. The intercept coefficient in the equation of that line (CR = MR + 807) indicates that the base of the Moffett Road section is 807 ft above the base of the Cincinnati Region composite section.

In evaluating the precision of correlation implied by the conclusion just stated, it is important to comment briefly on the limits imposed by graphic analysis of the available conodont range-data and by the methods used to assemble the relative-abundance logs. As noted by Sweet (1983), the width of the array used in graphic correlation to compute the line of correlation between two sections, or between a section and a composite standard section, may be employed empirically as a measure of the limits of accuracy of the correlation indicated by the equation of that line. In figure 3 of this report it is clear that array width from graphic correlation of the Moffett Road and Cincinnati

Region composite standard sections is 12 ft (the distance on the X-axis between the intercepts of the dashed lines through B22 and T60). This may be taken to mean that points in the Moffett Road section can be located with confidence in the Cincinnati Region composite standard section only within an interval of the latter section 12 ft thick.

Relative-abundance analysis, effected in figure 4 by visual comparison of logs, attempts to narrow the interval of uncertainty by adjusting logs within the interval suggested by graphic-array width to a position of maximum significant match. In figure 4, maximum log match is achieved with the base of the Moffett Road log at a level 810 ft above the base of the Cincinnati Region composite section. However, it should be noted that successive points in the relative-abundance logs are five feet apart and summarize conodont frequencies in the 2.5 ft below and above their plotted positions. Consequently, the actual positions of the inflection points identified in figure 4, listed in table 2, and plotted in figure 3 may be as much as 2.5 ft lower or higher than plotted. In brief, even with use of inflection points from relative-abundance logs, the interval of correlation uncertainty can be narrowed only to five feet. Thus, the base of the Moffett Road section might correlate with a level as low as 807.5 ft, or as high as 812.5 ft above the base of the Cincinnati Region composite standard section. Because the X-intercept of the dashed line through T60, in figure 3, indicates that the base of the Moffett Road section is no lower than a level 807 ft above the base of the Cincinnati Region composite section, it is concluded that the equation, CR = MR + 807, best expresses the correlation between these sections.

Stadial Classification and Stratotypes

The Kope Formation in the vicinity of Eden Park, Cincinnati, is the stratotype of the Edenian Stage, the oldest of the four stages into which the Late Ordovician Cincinnatian Series is divided in North America (Ross et al., 1982). Unfortunately, the base of the Kope is no longer exposed near Eden Park and limited exposures of it elsewhere near Cincinnati, such as the one along Banklick Creek in northern Kenton County, Kentucky (Sweet, 1979a; fig. 1, locality 28), are difficult to relate to the main body either of the Kope or the subjacent Point Pleasant Tongue of the Clays Ferry Formation. Thus, in various biostratigraphic summaries (e.g., Sweet and Bergstrom, 1971; Sweet, 1979a; Ross et al., 1982) we have followed Ford (1967) in assuming that the base of the Kope in Cincinnati is about 230 feet below the base of the Fairview Formation in the type section of the latter along Clifton Avenue, in Cincinnati.

Correlation of the Moffett Road section indicated in figures 3 and 4 generally confirms previous assumptions about the thickness of the Kope Formation in the immediate vicinity of Cincinnati, Ohio, but indicates that the base of the Kope is about 239 ft below the projected level of the type-Fairview base, and that the stratotype of the Edenian Stage is thus 239 ft, rather than 230 ft, thick. The base of the Edenian Stage would then be at a level 861 ft above the base of the Cincinnati Region composite standard section (fig. 4), rather than at 870 ft as has been previously assumed.

If the basal contact of the Kope Formation in the Moffett Road section were established as the stratotype for the base of the Edenian Stage (and Cincinnatian Series), and if the correlations between Ordovician rocks of the Cincinnati Region and the Trenton Group of New York and Ontario suggested by Sweet and Bergstrom (1971) and more recently by Sweet (1982) and Ross et al. (1982) are correct, it is of interest to note that the Edenian base would

project to a level less than one foot below that of the top of the type Shermanian Stage at Trenton Falls, New York. Because such a difference is far too small to be resolved in our current conodont-based biostratigraphic framework, it may be concluded that fixing the base of the Edenian Stage (and the Cincinnatian Series) at the base of the Kope Formation in the Moffett Road section, and adoption of a 239-ft thickness for the Kope Formation in the vicinity of the Edenian type section, would result in unusually precise definition of the boundary between the Middle and Upper Ordovician in North America.

On the other hand, the writer does not agree with Pojeta's (1981) suggestion that the Kope Formation exposed in the Moffett Road section be regarded as a stratotype for the Edenian Stage. Obviously, as indicated in figure 4, the top of the Kope Formation in the Moffett Road section is more than 20 feet above the level of the base of the Fairview Formation in its type section in Cincinnati, which has been taken as the base of the mid-Cincinnatian Maysvillian Stage for nearly 80 years. Furthermore, the Kope Formation was only partially exposed in the Moffett Road section in 1969, when it was sampled in detail, and is even less well exposed now; and there appears to be a difference of opinion as to the level of its top, even among those who participated in that sampling program.

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APPENDIX A

Sample by Sample Distribution and Frequency of Conodont Species in Moffett Road (MR) Section

USGS Sample	Lithology (sh = shale; ls=limestone)	Ft. above base of MR section	Species-Number of specimens (Species numbers from table 1) (Entry "4-1" means 1 spm. species 4)	Sample Total
8396	sh	0.0-0.5	4-1	1
8397	sh	0.5-1.1	4-8; 36-3; 48-2; 64-16; 69-9; 82-1	39
8068	sh	1.1-2.1	4-25; 26-2; 36-11; 64-125; 69-42	205
8398	sh	2.1-2.8	4-15; 36-7; 64-64; 69-16; 102-1	103
8399	sh	2.8-3.5	4-1; 36-2; 64-16; 69-2	21
8400	ls	3.5-4.7	4-38; 36-17; 40-1; 64-580; 69-75	711
8401	ls,sh	4.5-5.7	4-46; 36-4; 40-3; 59-1; 64-527; 69-45;98-2	628
8402,3,5	ls,sh	7.7	4-88; 36-8; 40-1; 48-13; 64-886; 69-93	1089
8406,7	sh	10.3	4-5; 36-9; 48-3; 64-35; 69-8	60
8408	sh	12.3	4-9; 48-2; 64-11; 69-5	27
8409	ls,sh	13.3	4-75; 40-3; OV-7; 48-2; 64-1247; 69-132; 98-3	1469
8410	sh	13.8	4-15; 36-4; 40-1; 64-73; 69-16	109
8411	ls	14.4	4-7; 36-1; 40-1; OV-3; 64-383; 69-16	411
8412	ls,sh	14.9	4-119; 36-26; 40-8; 48-6; 64-1552; 69-109	1820
8413	sh	15.9	4-1; 64-26; 69-10	37
8414	sh	16.9	4-42; 48-5; 64-73; 69-17	137
8415	sh	20.0	64-1; 69-2	3
8416	ls	21.8	4-11; 36-2; OV-2; 48-6; 64-293; 69-56	370
8417	sh	22.8	36-2; 64-10; 69-1	13
8418	ls,sh	23.3	4-42; 36-24; 48-2; 64-358; 69-86; 98-1	513
8419	sh	25.6	4-1; 36-2; 64-16; 69-4	23
8420	ls,sh	26.2	4-55; 10-2; 36-5; 48-11; 64-84; 69-46	203
8421	sh	28.0	4-8; 36-6; 48-1; 64-19; 69-9	43
8422	ls,sh	28.2	4-34; 10-1; 36-13; OV-2; 48-8; 64-448; 69-64	570
8423	ls	28.9	4-6; 36-5; 48-2; 64-203; 69-27	243
8424	sh	29.4	4-13; 36-5; 48-7; 64-43; 69-16; 98-1	85
8425	sh	29.9	4-8; 36-9; 48-1; 64-20; 69-8	46
8426	sh	30.0	4-1; 36-2; 48-1; 64-20; 69-7	31
8427	ls,sh	31.5	4-103; 36-11; 40-4; 48-1; 64-732; 69-174	1025
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