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CARBONATE MICROFACIES OF THE PLATTEVILLE GROUP (MIDDLE ORDOVICIAN), LEE AND LASALLE COUNTIES, ILLINOIS

BY

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ABSTRACT

The Platteville Group (Middle Ordovician) in the Dixon and Troy Grove areas was sampled at a vertical interval of 7.4 centimeters with 951 samples collected to determine its depositional environment. The Platteville carbonates consist of a cyclic repetition of eight microfacies which occur in two autochthonous groups, plus a third allochthonous group. The first group, in order of decreasing relative depth, consists of: a fine calcisiltite with scattered bioclasts (Microfacies N-1), a mud-supported biocalcarenite with a fine calcisiltite matrix (Microfacies N-2), a grain-supported biocalcarenite with a fine calcisiltite matrix (Microfacies N-3), and is generally characterized by a noncomminuting type of bioturbation. The second group of microfacies closely resembles the first group and consists of: a fine to medium calcisiltite with scattered bioclasts (Microfacies C-1), a mud-supported biocalcarenite with a fine to medium calcisiltite matrix (Microfacies C-2), a grain-supported biocalcarenite with a fine to medium calcisiltite matrix (Microfacies C-3), and is generally characterized by a comminuting type of bioturbation. The allochthonous group of microfacies consists of: a grain-supported litho-biocalcarenite with a combination of recrystallized calcisiltite, syntaxial overgrowths and void-filling sparite cement (Microfacies 4) and a medium to coarse grain-supported pelletoidal biocalcarenite with recrystallized calcisiltite and sparite cement (Microfacies 5); both microfacies occur as turbidite-like layers.

Organic and inorganic microscopic components were measured for frequency and clasticity (where applicable). The relative intensity and types of bioturbation, the occurrence of six petrographically recognizable types of burrow fillings, and the relative abundance of phosphate were also recorded. These data were computer plotted beside a columnar section as curves showing stratigraphic variation of the components. The combination of these measurements with the above microfacies classification provides evidence to support a relative depth curve which represents the final interpretation of the environment of deposition.

Six of the microfacies combine to form a depositional sequence which is interpreted as a superposed tripartite stratigraphic sequence of the two models. The occurrence of the seventh

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and eighth microfacies (Microfacies 4 and 5) represents turbidite-like interruptions in the normal sequence. The two models are similar, consisting of a relatively flat and gently sloping infratidal environment with open marine conditions and having an inferred shoreline. The models are distinguished by the dominant type of bioturbation: the Noncomminuted Model and the Comminuted Model. The models differ in the shape of the inferred open marine side and their general relative depth, with the Comminuted Model occupying a shallower position in the infratidal zone. An inferred submerged barrier bar occurs on the open ocean side of the Noncomminuted Model occupying the basal position of the tripartite sequence. The medial position is occupied by the Comminuted Model which displays a break in slope on the open marine side. The break in slope and the generally shallower depth of the Comminuted Model are the final influence of the submerged barrier bar. The upper position of the tripartite sequence marks the return of the Noncomminuted Model which now lacks the submerged barrier bar.

The noncomminuted sequence displays more stable depositional conditions with minor fluctuations, in contrast to the comminuted sequences which show cyclic sedimentation. The relative depth curve for the tripartite sequence of models represents an overall transgression which has been temporarily interrupted by a shallower depositional environment.

The tripartite sequence of models correlates with Platteville Group stratigraphy as follows: the basal noncomminuted sequence correlates with the Pecatonica Formation, the medial comminuted sequence matches up with the Mifflin Formation and most of the Grand Detour Formation, and the upper noncomminuted sequence correlates with the remaining upper portion of the Grand Detour plus the Nachusa and Quimbys Mill Formations.

Petrographic evidence supports an early post-depositional mechanism of dolomitization such as Badiozamani's Dorag dolomitization model.

RÉSUMÉ

Le Groupe de Platteville (Ordovicien moyen) dans la région de Dixon et de Troy Grove a été échantillonné à un intervalle vertical de 7,4 cm avec 951 échantillons utilisés pour établir son milieu de sédimentation. Les carbonates de Platteville représentent la répétition cyclique de huit microfaciès qui se divisent en deux groupes autochtones et un groupe allochtone. Le premier groupe comprend par ordre de profondeur relative décroissante: calcisiltite fine à bioclastes dispersés (microfaciès N-1), biocalcarénite à grains non jointifs et à fine matrice calcisiltique (microfaciès N-2), biocalcarénite à grains jointifs et à fine matrice calcisiltique (microfaciès N-3); ce groupe se caractérise par un type de bioturbation non fragmentaire. Le second groupe de microfaciès est très semblable au premier et comprend: calcisiltite fine à moyenne à bioclastes dispersés (microfaciès C-1), biocalcarénite à grains non jointifs et à matrice calcisiltique fine à moyenne (microfaciès C-2), biocalcarénite à grains jointifs et à matrice calcisiltique fine à moyenne (microfaciès C-3); ce groupe se caractérise par un type de bioturbation fragmentaire. Le groupe de microfaciès allochtones comprend: litho-biocalcarénite avec une association de calcisiltite recristallisée, auréoles d'accroissement secondaire et ciment sparitique de remplissage de cavités (microfaciès 4), biocalcarénite pelletoïdale à calcisiltite recristallisée et ciment sparitique (microfaciès 5); ces deux microfaciès forment des niveaux ressemblant à des turbidites.

Les paramètres suivants ont été mesurés: fréquence et clasticité des composants microscopiques organiques et inorganiques, intensité relative et types de bioturbation, présence de six types pétrographiques de remplissage de terriers de fouisseurs et abondance relative des débris phosphatés. Ces valeurs donnent lieu à des courbes tracées par ordinateur et placées à droite de la colonne lithologique exprimant la variation stratigraphique de ces paramètres. La combinaison de ces mesures avec la classification texturale des microfaciès permet de tracer une courbe bathymétrique relative qui représente l'interprétation finale du milieu de sédimentation.

Six des microfaciès s'associent pour former une série sédimentaire interprétée comme une séquence stratigraphique tripartite formée par les deux modèles de dépôt. Les deux autres microfaciès (microfaciès 4 et 5) représentent des sédiments semblables à des turbidites qui interrompent la succession normale. Les deux modèles sont semblables et comprennent un milieu infracotidal à pente relativement douce s'étendant d'une ligne côtière supposée à un milieu marin ouvert. Les modèles se distinguent par le type prédominant de bioturbation; modèle non fragmentaire et modèle fragmentaire. Ils diffèrent par la forme de leur partie marine ouverte et par la profondeur générale relative, le modèle fragmentaire occupant une position moins profonde dans la zone infracotidale. Une barre submergée constitue le côté mer ouverte du modèle non fragmentaire qui occupe la partie basale de la séquence tripartite. La partie médiane est formée par le modèle fragmentaire qui montre simplement une rupture de pente du côté mer ouverte. Cette rupture de pente et la profondeur générale plus faible du modèle fragmentaire représentent les derniers effets de la barre submergée. La partie supérieure de la séquence tripartite marque le retour du modèle non fragmentaire qui ne montre plus de traces de la barre submergée.

Le milieu à bioturbation non fragmentaire montre des conditions de sédimentation plus stables avec des fluctuations mineures tandis que ceux à bioturbation fragmentaire sont cycliques. La courbe bathymétrique relative de la superposition tripartite esquisse une transgression générale temporairement interrompue par un épisode de profondeur plus faible.

La séquence tripartite des modèles présente avec la stratigraphie du Groupe de Platteville les corrélations suivantes: le milieu basal non fragmentaire correspond à la *Pecatonica Formation*, le milieu médian fragmentaire correspond à la *Mifflin Formation* et à la plus grande partie de la *Grand Detour Formation*, le milieu supérieur non fragmentaire correspond au reste de la partie supérieure de la *Grand Detour Formation* et aux *Nachusa* et *Quimbys Mill Formations*.

Les observations pétrographiques indiquent un processus de dolomitisation post-sédimentaire précoce semblable au modèle Dorag proposé par Badiozamani.

INTRODUCTION

The purpose of this study lies in the following areas: determination of the relationship between the microfacies recognized in this study and the present stratigraphic classification of the Platteville Group (Templeton and Willman, 1963, p. 64) based on relative argillaceousness; development of a depositional model for the Platteville Group through interpretation of temporal (stratigraphic) relationships between the microfacies; determination of the relationship between the extensive bioturbation of the Platteville sequence and the recognized microfacies; and the elucidation of the probable mechanism of dolomitization which has affected the Platteville sequence.

LOCATION

The present study is concerned with two areas belonging to the Platteville outcrop belt of north-central Illinois. The first area, centering on Dixon, Illinois (Fig. 1) includes the sections of the Medusa Cement Quarry, "Dixon North" and "Dixon East" (Templeton and Willman, 1963, pp. 230, 234-235) and "River Street" (Templeton and Willman, 1952, p. 18). The second area is located at Troy Grove, Illinois (Fig. 1) where the Troy Grove Stone Quarry displays the dolomite facies of the Platteville Group (Buschbach *in* Odom *et al.*, 1970, p. 21). Also investigated was the "Deer Park" section in Matthiesen State Park (Templeton and Willman, 1963, pp. 230-231) where the Pecatonica Formation is atypically characterized by brecciated units overlain by calcarenites.

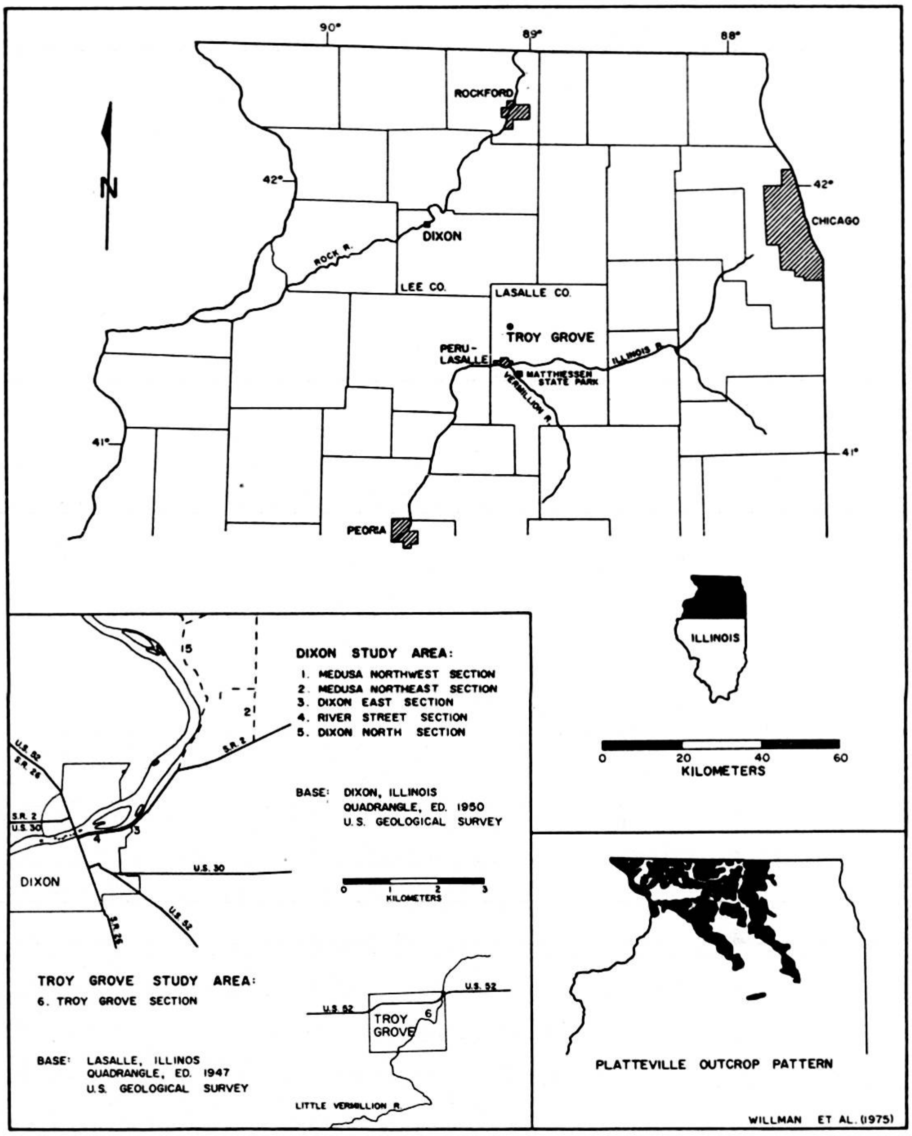

FIG. 1. — Location map.

TECTONIC SETTING

The northern exposures of the Platteville Group lie within the Eastern Stable Interior of North America and crop out in an arcuate pattern. The Platteville rocks have a gentle southern dip resulting from their location on the southern slope of the Wisconsin Arch and the northern edge of the Illinois Basin. Smaller structural features, such as the Savanna and Oregon anticlines and the Ashton Arch, located in or near the study area underwent several minor uplifts during deposition of the Platteville causing unconformities, diastems, and abrupt changes in sedimentation (Templeton and Willman, 1963, pp. 136-137).

Nearly all the bedrock in the study area is covered by Pleistocene glacial deposits. This, coupled with generally low relief and relatively dense vegetation, limits Platteville exposures to quarries, newer roadcuts, and some areas where rivers have eroded through the glacial material and into the underlying bedrock.

REVIEW OF PREVIOUS WORK

The sequence of carbonate rocks comprising the Platteville Group has received the attention of numerous workers during the last one hundred years. The evolution of the stratigraphic nomenclature is discussed in detail by Templeton and Willman

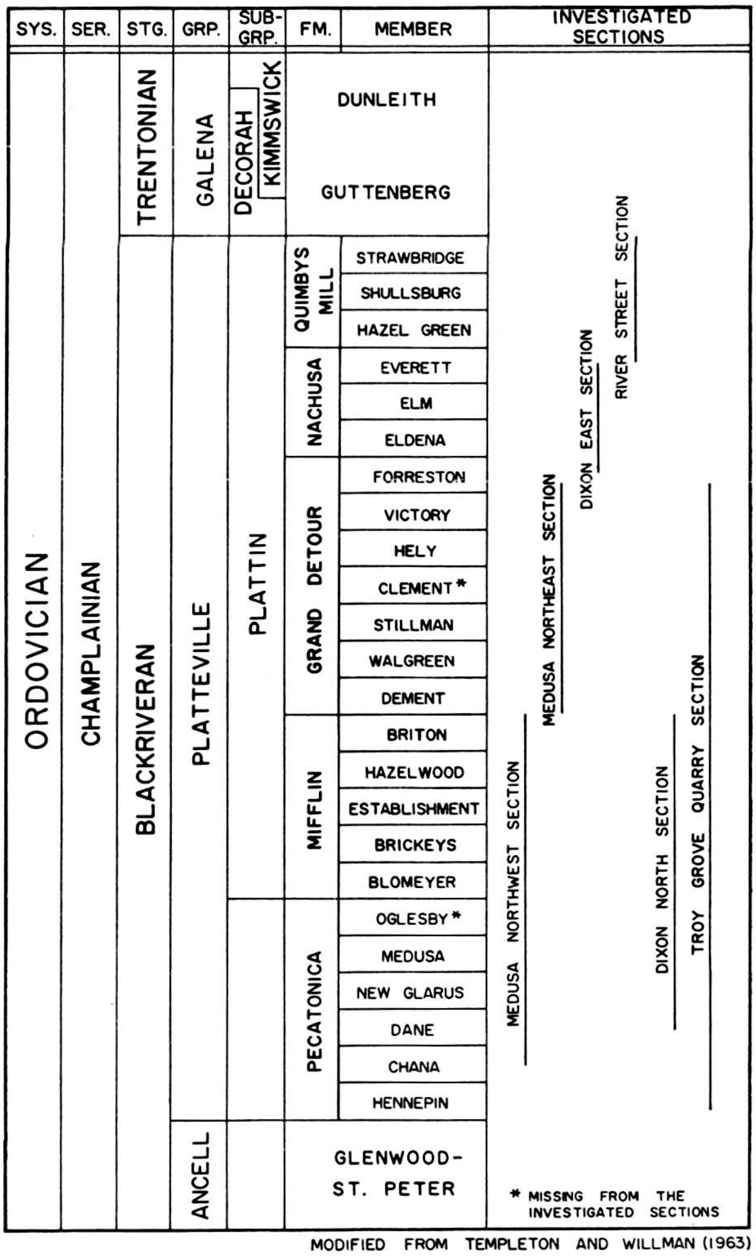

FIG. 2. — General stratigraphy of the Platteville Group.

(1963) and Willman *et al.* (1975). These authors have developed the presently recognized five formations divided into 24 members (Fig. 2).

Ziemba (1955) and Carozzi (1956 and in Wanless *et al.*, 1957, pp. 68-81) have done the most comprehensive petrographic studies of the Platteville Group carbonates. Ziemba divided the Platteville carbonates into five textural groups whereas Carozzi divided the same rocks into four textural groups. Both textural classifications infer relative depth of deposition. Carozzi also described nine cycles of depth fluctuation within the Platteville sequence (Wanless *et al.*, 1957, p. 78).

The mechanisms of dolomitization that have been suggested for the Platteville sequence are: penecontemporaneous and early diagenetic, with the latter being more important (Asquith, 1967, p. 311); post-lithification ground water circulation (Deininger, 1964, p. 281; Ziemba, 1955, p. 41, and Griffin, 1942, p. 67); hydrothermal solutions associated with lead-zinc mineralization (Agnew *et al.*, 1956, p. 257 and Heyl *et al.*, 1959, p. 96); and mixing of meteoric ground water with sea water in the phreatic zone (Badiozamani, 1973, p. 969). The latter (1973, p. 968) has suggested that when meteoric ground water is mixed with up to 30% sea water the mixture is less saturated with respect to calcite, whereas the dolomite saturation continuously increases. Badiozamani's "Dorag" dolomitization model is dependent on areas of subaerial exposure associated with structural highs (in the case of the Platteville sequence) to provide a source of fresh water.

Most environmental interpretations of the Platteville carbonates by previous workers have been generalizations or peripheral comments included in stratigraphic investigations (Carozzi and Textoris, 1967, p. 9; Asquith, 1967, p. 325; Agnew *et al.*, 1956). The general consensus of these studies is that the Platteville was deposited in a shallow, low energy, subtidal environment. Kolata (1973, p. 28 and 1975, p. 11) in combining paleontological evidence with existing stratigraphic and sedimentological evidence, suggested the Platteville environment was also flat-bottomed with low depositional slopes and related to a slowly subsiding basin and/or regional transgression.

The extensive bioturbation of Platteville carbonates has largely been neglected. Some notable exceptions are Fraser (1974, p. 116) who described burrows in the Pecatonica Formation, Kolata (1973, p. 29) who pointed out extensive biogenic activity indicated by Platteville textures, and Griffin (1942, p. 74) who mentions the possible relationship of the dolomitization to animal burrowing.

STRATIGRAPHY AND SEDIMENTOLOGY

The Platteville sequence, in the study areas, rests unconformably on the Glenwood Formation or the St. Peter Sandstone (both contained in the Ancell Group), and in turn is unconformably overlain by the Galena Group dolomite. A regional diastem occurs at the top of the other four Platteville formations (Mifflin [lowest], Grand Detour, Nachusa, and Quimbys Mill) which are collectively referred to as the Plattin Subgroup (Fig. 2).

Templeton and Willman (1963, p. 19), after compiling detailed descriptions of Platteville sections in Illinois and surrounding states, found that the Platteville Group can be best classified into rock-stratigraphic units based on the cyclic differences in clay content. The Platteville appears to be composed of alternating argillaceous and "pure" carbonate units (five formations and 24 members). The argillaceous units are generally thinner bedded, finer-grained and less dolomitic than the pure carbonate units. Nodular chert is most commonly associated with moderately argillaceous units, and along with the litho-biocalcarenites and corrosion surfaces (described as corrosion zones by Weiss, 1954 and 1958), can be useful in identifying the various Platteville units. Templeton and Willman (1963, pp. 136-137) noted that individual units of pure carbonate and argillaceous carbonate rocks are traceable over large distances in the stable interior. They interpreted this as indicating very uniform sedimentation over large areas during deposition of the Platteville Group and considered diastrophism in adjacent positive areas (such as the Wisconsin Arch) as the major factor in the origin of alternating units of pure and argillaceous carbonate sediments.

In the Dixon area, the following general sedimentological features are observed. The Pecatonica Formation is 7.4 meters thick, its lower part is fine-grained, thin-bedded and very argillaceous dolomite, which grades upward into a medium- to thick-bedded, fine-grained limestone which is much less argillaceous and moderately fossiliferous. The basal Pecatonica contains fine to medium, well rounded quartz grains (St. Peter-type) associated with burrows and common to abundant reddish detrital phosphate. The upper boundary of the Pecatonica Formation is characterized by a ferruginous, burrowed and/or solution-pitted corrosion surface with common to abundant detrital quartz and phosphate.

The overlying Mifflin Formation (3.1 meters thick) is a fine-grained, thin wavy-bedded limestone, extremely argillaceous (shaly partings) and very fossiliferous with extensive bioturbation. Numerous litho-biocalcarenites occur throughout the formation. A well defined and graded biocalcarenite approximately 7 centimeters thick, occurs at the upper contact of the Mifflin and is persistent throughout the Dixon area.

The Grand Detour Formation (15.9 meters thick) is fine-grained, cherty, dolomite-mottled (dolomitized burrows) limestone that grades into medium-grained dolomite in the upper portion (Forreston Member) of the formation. Argillaceous units are thin-bedded and shaly, whereas the less argillaceous units are medium- to thick-bedded. Biocalcarenite layers occur throughout the Grand Detour which is moderately fossiliferous in some units (Walgreen and Forreston Members).

Both the Nachusa Formation (5.4 meters thick) and the Quimbys Mill Formation (2.9 meters thick) are completely dolomitized. The Nachusa is a somewhat argillaceous and cherty (nodular), thick-bedded to massive, medium-grained dolomite. Coarse-grained dolomite is often associated with burrows. The overlying Quimbys Mill is a more argillaceous, thin- to medium-bedded, fine-grained dolomite which is often well-laminated. The uppermost part of the formation is a more massive, medium-grained, fossiliferous dolomite.

METHODS OF STUDY

SAMPLING TECHNIQUES

A total of 951 vertically oriented hand specimens were collected from 109 fields units distinguished in several stratigraphic sections totalling 70.7 meters in thickness. 512 samples from 59 fields units totalling 41.6 meters were collected in the Dixon area, while 439 samples from 50 field units totalling 29.1 meters came from the Troy Grove area.

The relative thinness (approximately 35 meters) of the Platteville Group in the study areas, allowed the use of a small sampling interval. The vertical spacing of samples is primarily a function of lithology, and has an overall average of 7.4 centimeters (the Dixon area average is 8.1 centimeters whereas the Troy Grove area average is 6.6 centimeters).

A sample interval of approximately 30 centimeters was mathematically simulated from the existing sample population (in the Dixon area) to determine the effect of a larger sample interval for the Platteville sequence. The larger sample interval failed to detect a thin pelletoidal unit classified as microfacies 5. Microfacies 5 is the least important member of the microfacies classification proposed for the Platteville because of its infrequent occurrence.

PETROGRAPHIC ANALYSIS

Thin sections (perpendicular to bedding) were prepared from the vertically oriented samples, and studied following the method proposed by Carozzi (1950, 1958, and 1961), which consists of tabulating indices of frequency and clasticity of all detrital components, and the frequency index for all benthonic and pelagic organic components (whole or broken) of a carbonate rock.

The index of clasticity for any given component is defined as the maximum diameter of the component. In the case of thin sections, this apparent diameter only approximates the actual diameter of the particular component (the actual diameter is observed only where a thin section cuts through the center of a grain). Therefore, the index of clasticity is consistently less than the maximum diameter. Consistency in the measurement of the clasticity index of a particular component is achieved by taking the average diameter of the six largest grains in a particular thin section.

Grains notably larger than those ordinarily found in a particular rock are considered atypical of the depositional agents for the overall environment, and are not calculated in clasticity indexes. The latter are listed as figures (in millimeters) which represent the largest diameter of a grain that could be set in motion by the average hydraulic forces acting in the environment of deposition.

The frequency index of a given component is defined as the number of its particles present in a constant area of a thin section, and requires the counting of those particles found in that particular area for each thin section. A minimum of 100 or more particles must be counted to insure statistical reliability. An inherent weakness of this method of frequency determination occurs in rocks predominantly composed of closely packed grains of a particular component. As the grain-size increases, the frequency index will decrease, giving a misleading value. This problem can be alleviated by selecting an area for each component that has a diameter at least 10 times the average diameter of that particular component. In the present study, the standard surface area used for all components is 230.8 square millimeters.

The thin sections were initially scanned in stratigraphic order and placed in preliminary microfacies based on frequency and type of biogenic and lithic components, and the type of matrix (micrite versus sparite or pseudospar). Component frequency and clasticity measurements were made on thin sections in each of the preliminary microfacies. This procedure gives a better understanding of the constitution and limitations of each of the microfacies. After all the thin sections were studied in detail and statistical parameters computed, eight microfacies were established.

The thin sections, with their respective microfacies designation, were placed in their proper stratigraphic sequence so temporal relationships between the microfacies could be determined and models for the environment of deposition for the Platteville Group could be formulated.

Statistical analysis and computer techniques

Analysis of petrographic data for this study was facilitated by application of computer techniques. An IBM 360/75 computer at the University of Illinois, Urbana, and an IBM 370/165 computer, through the KECNET (Kentucky Educational Computer Network) system at the University of Louisville, were used for all computations.

An iteration program written by Demirmen (1969), was used to objectively scrutinize the validity of the proposed microfacies classification. After the iterations had stabilized, those thin sections that were not consistent with both the proposed microfacies classification and the computer "check" of the classification, were re-examined to determine if reclassification of the thin sections into different microfacies was warranted. The interrelationships of the microfacies were verified by bivariate correlation analysis through the use of the subroutine PEARSON CORR of the SPSS (Statistical Package for the Social Sciences) program written by Nie and others (1975).

Statistical computations were facilitated by the CONDESCRIPTIVE subroutine of the same SPSS program. Mean values for the measured components of each microfacies were standardized using the following formula:

$$Z = \frac{(\overline{Y} - \mu)}{\sigma}$$

Z is the standardized value. $\overline{Y}$ is the mean for one component in a single microfacies, μ is the mean for that component using all the samples, and σ is the standard deviation of that component for all samples. The advantage of using Z values lies in the easy comparison and graphic representation of data, regardless of large variations in the mean values for those components. This results from the standardized value (Z) having a mean of zero and a standard deviation of one, for any component.

The curves expressing stratigraphic variations of measured petrographic components (Figures 6 through 13) were drawn on 90 centimeter-wide paper by a Calcomp 936 Zip Mode Plotter using a modification of previously written programs (Rao and Carozzi, 1971; Nowak and Carozzi, 1973; Stricker and Carozzi, 1973). Microfacies have been arranged to the right of each set of variation curves, and represent a relative decrease in depth from left to right. The constant spacing between microfacies is used only to facilitate their plotting, and does not imply a constant decrease in relative depth. Depth changes between microfacies do not lend themselves to accurate quantification.

COMPONENTS

The boundary between carbonate skeletal material and matrix material was arbitrarily set at 60 microns (approximately the sand-silt boundary) because of the difficulty in identifying and counting skeletal debris below that size. Extensive recrystallization of much of the skeletal debris made identification of particles in the smaller size range extremely difficult.

Major organic components

The major biogenic components are pelmatozoans (various classes of echinoderms could not be differentiated in this study), brachiopods, bryozoans, arthropods (ostracods and trilobites), and mollusks (mostly gastropods and pelecypods). This diverse fauna is ubiquitous in all the microfacies, with the bryozoans, trilobites, and pelecypods being somewhat less abundant.

Calcareous green algae *(Vermiporella)* occur mostly in the C-1, C-2, and C-3 microfacies, but are most abundant in the latter.

Minor organic components

Minor biogenic components include cephalopods, sponge spicules, and one instance of *Girvanella*. These components are scattered throughout the sections investigated in the Dixon area. The occurrence of these minor components was too infrequent to justify tabulation, but they were considered in conjunction with the major components during environmental interpretation.

Inorganic components

Angular, silt-sized, detrital quartz is the most common inorganic component and occurs in all the microfacies. Fine- to medium-sized, well-rounded, St. Peter-type quartz grains occur in most of the microfacies, and in most instances are associated with burrowed sediments adjacent to diastemic or unconformable boundaries.

Pellets, mostly fecal in origin, are extremely abundant in microfacies 4 and microfacies 5 (pelletoidal), and occur in minor amounts in some of the other microfacies. A merged pellet texture was observed in some thin sections of the "C" series microfacies. This indicates the possibility of those microfacies having some portion of their matrix composed of completely merged pellets.

Lithoclasts occur as subangular to well-rounded fragments of Platteville lithologies. They are most abundant in microfacies 4 (litho-biocalcarenite), and have only minor scattered occurrences in most of the other microfacies.

Detrital phosphate, ranging from yellow to bright red, is widespread throughout most of the investigated sections. The relative abundance (from none to very abundant) has been estimated for each thin section, and the phosphate was found to be most abundant in rocks adjacent to diastemic or unconformable boundaries.

DIAGENESIS

The major diagenetic processes affecting the Platteville sequence are bioturbation and dolomitization. Silicification, producing discontinuous beds of nodular chert scattered throughout the Platteville (in the study areas), is best developed in the Pecatonica Formation at Troy Grove.

Bioturbation

Bioturbation is extensive throughout most of the Platteville Group in both the Dixon and Troy Grove study areas. The microfacies have been grouped into a noncomminuted series (N-1, N-2 and N-3) where biogenic debris has not undergone extensive breakage caused by burrowing (Plate 1, A), and a comminuted series (C-1, C-2 and C-3) in which extensive breakage of biogenic debris has resulted from foraging of organisms (Plate 1, B). The "N" or "C" prefix designates to which series (noncomminuted or comminuted) the microfacies belongs. Microfacies 4 and 5 are considered noncomminuted, but their allochthonous nature precludes their being included in the noncomminuted series.

Six petrographic varieties of burrow fillings have been recognized and tabulated (Figures 6 through 13). They are characterized as follows:

Variety 1: Generally medium crystalline, anhedral to subhedral dolomite crystals, some of which are zoned with a dark center (Plate 1, C).

Variety 2: Characterized by generally large burrows filled with medium to very coarsely crystalline calcite with a very distinctive "cauliflower-like" appearance (Plate 1, D). Crystal boundaries generally are marked by the presence of iron-oxide and/or clay minerals. This variety of burrow filling is in many cases associated with variety 1, and some show the development of incipient euhedral dolomite crystals.

Variety 3: Generally a finely crystalline pseudospar that is somewhat clearer than the surrounding calcisiltite matrix (Plate 1, E).

Variety 4: Medium crystalline sparry calcite that in some cases forms geopetal structures in the burrows (Plate 1, F). This variety of burrow is generally associated with varieties 3 and 5.

Variety 5: Burrows containing biogenic debris and/or pellets (Plate 2, A). Either pseudospar or sparry calcite is generally found in this variety of burrow filling.

Variety 6: Characterized by burrows through comminuted debris where the parallel alignment of debris with burrow walls causes whorls or spiral patterns (Plate 2, B).

The different petrographic varieties of burrow fillings are in many cases associated to each other (such as varieties 1 and 2, varieties 3 and 4, and varieties 3, 4, and 5) and appear indigenous to both the noncomminuted and comminuted series of microfacies. One exception is variety 6 which appears to be closely related to the comminuted series of microfacies.

Dolomitization

Complete dolomitization occurs in the basal portion of the Pecatonica Formation the upper portion of the Grand Detour Formation, and the Nachusa and Quimbys

Mill Formations in the Dixon area. The remainder of the Platteville sequence, at Dixon, has undergone varying amounts of partial dolomitization.

The completely dolomitized portions of the Platteville, including the complete Troy Section Grove, are characterized by: fine to medium crystalline, anhedral to subhedral dolomite (Plate 2, C); medium to coarse crystalline, anhedral to subhedral dolomite (Plate 2, D); very coarse crystalline, generally subhedral to euhedral dolomite with moldic porosity (Plate 2, E), and still retain many of the macroscopic characteristics of the Platteville limestone facies. The fine to medium crystalline dolomite represents the dolomitization of mud-supported or grain-supported biocalcarenites. The very coarse crystalline dolomite was produced by the dolomitization of litho-biocalcarenites. The dolomite crystals that line or completely fill the fossil molds are zoned, with cloudy dolomite at the center changing to limpid dolomite toward the margins (Plate 2, E).

Partially dolomitized portions of the Platteville Group in the Dixon area are characterized by two general types of dolomite. The first type is associated with argillaceous units and consists of fine to medium crystalline, anhedral to somewhat subhedral dolomite having iron oxide (oxidized pyrite) and clay minerals along the crystal boundaries (similar in appearance to the laminated dolomite shown in Plate 2, F). The second type of dolomite is associated with "clean" calcisiltite units and consists of euhedral, generally fine to medium sized crystals, many of which are zoned (Plate 2, F). The clean calcisiltite units show a decrease in dolomitization from the boundaries inward toward the centers of these units.

The Nachusa Formation, at Dixon, contains some well-laminated, fine to medium crystalline dolosiltite (Plate 2, G) with only limited burrowing. This laminated dolosiltite appears to have been deposited in an infratidal open marine environment because of its diverse fauna, occurrence of small mounds of pelmatozoan debris, and the lack of intertidal or supratidal indicators such as desiccation cracks or fenestral structures. These dolosiltite layers most likely were deposited by low energy currents sweeping low areas within a somewhat hummocky infratidal open marine environment.

As previously mentioned, Platteville dolomitization has been labelled penecontemporaneous, early diagenetic, and late diagenetic (post-lithification). The petrographic and faunal evidence should be first presented.

The Platteville Group carbonates in the study areas are characterized by a diverse open marine fauna, regardless of whether the sequence is limestone or dolostone. The same conclusion was reached by Kolata (1973, p. 26), Fraser (1974, p. 117), and Badiozamani (1973, p. 971) in their studies of portions of the Platteville sequence. The faunal evidence and the lack of any evidence, such as desiccation cracks or fenestral structures, suggesting an evaporative or supratidal environment, rules out primary precipitation as a mechanism of dolomitization. No lead or zinc sulfide mineralization has been observed in the Dixon or Troy Grove sections, and none has been reported in the literature for these areas. Therefore, the hydrothermal solutions associated with lead and zinc mineralization in the Upper Mississippi Valley do not appear to be a mechanism of dolomitization in the study areas. Late diagenetic alteration by ground water circulation occurs along joints and some bedding planes. Its overall effect on dolomitization of the Platteville sequence in the Dixon and Troy Grove areas appears to be minimal, and therefore, cannot be considered a major mechanism of dolomitization.

Petrographic evidence, as well as the previously mentioned faunal evidence, supports a post-depositional time for the major dolomitization of the Platteville sequence in the Dixon and Troy Grove areas. Euhedral dolomite crystals commonly transcend primary sedimentary structures and biogenic debris in areas of incipient dolomitization. Lithoclasts composed of calcisiltite or mud-supported biocalcarenite and displaying euhedral dolomite crystals truncated by the lithoclast's boundary (Plate 2, H), are found in some of the litho-biocalcarenites (Microfacies 4) of the Mifflin Formation. These lithoclasts closely resemble lithologies found in both the underlying Pecatonica Formation and the Mifflin itself. The lithoclasts, with their incipient dolomitization, are an excellent indicator of early postdepositional dolomitization.

The Dorag model is a satisfactory explanation of the origin of dolostones along positive elements or epicontinental shelves where meteoric ground water can be supplied by areas of subaerial exposure. The source of meteoric ground water to facilitate this dolomitization mechanism in the Dixon and Troy Grove areas is probably positive elements associated with the study areas. Evidence of intermittent subaerial exposure during Platteville deposition has previously been discussed. A Mg/Ca ratio of approximately 1:1 is associated with the Dorag model and thus eliminates the need for the often used restrictive (evaporative) environments (Adams and Rhodes, 1960, and Deffeyes *et al.*, 1965) to produce solutions with high Mg/Ca ratios. Folk and Land (1975, p. 64) suggest dolomite is better able to form when Mg/Ca ratios are nearer to 1:1 and the dolomitization process is slow. To date, the most probable answer for Platteville dolomitization in the Dixon and Troy Grove areas is the Dorag dolomitization model, or some basically similar mechanism.

DESCRIPTION OF MICROFACIES

The recognized microfacies are separated into the following three groups: (1) the noncomminuted series where each microfacies is designated by the letter "N" followed by a number, (2) the comminuted series where each microfacies is designated by the letter "C" followed by a number, and (3) a group of allochthonous microfacies labelled with the appropriate numbers. The noncomminuted and comminuted series resemble each other in many petrographic aspects, but were separated because of the distinctive overall types of bioturbation.

NONCOMMINUTED SERIES

The noncomminuted series of microfacies is characterized by bioturbation which has resulted in minimal breakage of bioclasts. Burrow fillings are most commonly characterized by dolomite crystals (variety 1) and finely crystalline pseudospar (variety 3), and less commonly by sparry calcite (variety 4) and biogenic debris and/or pellets (variety 5).

Microfacies N-1

Fine calcisiltite with scattered sand-size bioclasts (Plate 3, A). Identifiable bioclasts range up to 10% (the lower limit for microfacies N-2) and are mostly pelmatozoans, brachiopods, and ostracods. Lesser amounts of trilobites, bryozoans, gastropods, and pelecypods are present.

Angular, silt-size, detrital quartz grains are common, and some fine to medium St. Peter-type quartz grains are associated with burrows.

The calcisiltite matrix is finely crystalline and is often laminated in the argillaceous units.

Microfacies N-2

Mud-supported biocalcarenite with a fine calcisiltite matrix (Plate 3, B). Bioclasts are very similar to those of microfacies N-1, but with increased frequency. Trilobites, gastropods, and pelecypods are relatively more common than in microfacies N-1. The frequency of sand-size bioclasts ranges from 10% up to the occurrence of a grain-supported framework (approximately 30%).

Angular, silt-size, detrital quartz grains and St. Peter-type quartz grains reach their maximum frequency for the noncomminuted series.

The calcisiltite matrix is similar to that described in microfacies N-1.

Microfacies N-3

Grain-supported biocalcarenite with fine calcisiltite matrix (Plate 3, C). The most frequently occurring bioclasts are pelmatozoans, brachiopods, ostracods, trilobites, and gastropods, with lesser amounts of pelecypods and bryozoans. The minimum frequency of sand-size bioclasts is approximately 30%, or the first occurrence of a grain-supported framework.

The occurrence of angular, silt-size, detrital quartz has decreased from the frequency found in microfacies N-2 but is still common. St. Peter-type quartz grains, lithoclasts, and pellets have a minimal occurrence.

The matrix is the finely crystalline calcisiltite that is characteristic of the noncomminuted series of microfacies. The lack of abrasion of bioclasts and the preservation of delicate fossil debris suggests a low-energy environment dominated by *in situ* accumulations of biogenic debris for microfacies N-3 in particular, and the noncomminuted series of microfacies in general.

COMMINUTED SERIES

The comminuted series of microfacies is characterized by bioturbation which has caused extensive comminution and mixing of the biogenic debris. This results in characteristic spiral patterns (variety 6) of debris associated with burrows in the biocalcarenitic microfacies. Burrows filled with the previously described "cauliflowerlike" calcite (variety 2) are most commonly found in the comminuted microfacies. Dolomite (variety 1) and pseudospar (variety 3) are common constituents found in burrows for this series of microfacies, as well as the noncomminuted series.

The matrix for this series of microfacies is ordinarily bimodal being composed of finely crystalline calcisiltite and finely comminuted biogenic debris in the medium to coarse silt-size range. A matrix of merged pellets is observed in some thin sections. The pellets are easily observed in nearby burrows, which accounts for their relatively high frequency in microfacies C-2.

Microfacies C-1

Fine to medium calcisiltite with scattered sand-size bioclasts (Plate 3, D). Identifiable bioclasts range up to 10% (the lower limit for microfacies C-2) and are dominated by brachiopods, pelmatozoans, and ostracods, with lesser amount of trilobites, bryozoans, gastropods, and pelecypods.

Angular, silt-size, detrital quartz grains are common and exceed the maximum frequency (microfacies N-2) found in the noncomminuted series of microfacies.

Microfacies C-2

Mud-supported biocalcarenite with a fine to medium calcisiltite matrix (Plate 3, E). Dominant bioclasts are pelmatozoans, ostracods, brachiopods, trilobites, and gastropods, with bryozoans occurring in a lesser amount. This microfacies marks the first substantial occurrence of the alga *Vermiporella*, which is characteristic of the comminuted series of microfacies. The frequency of sand-size bioclasts ranges from 10% up to the occurrence of a grain-supported framework (approximately 30%).

Angular, silt-size quartz reaches its maximum frequency for the comminuted series of microfacies, and all microfacies.

Microfacies C-3

Grain-supported biocalcarenite with fine to medium calcisiltite matrix (Plate 3, F). *Vermiporella* has its maximum occurrence in this microfacies. Other major bioclasts are pelmatozoans, brachiopods, ostracods, gastropods, and trilobites. Pelecypods and bryozoans have lesser frequencies.

Angular, silt-size detrital quartz is somewhat less abundant in this microfacies than in microfacies C-2. St. Peter-type quartz grains occur in minor amounts.

Allochthonous group

Microfacies 4 and 5 are considered allochthonous because they represent temporary interruptions of the normal sequence of microfacies (the noncomminuted and comminuted microfacies) which are autochthonous. Bioturbation is generally very limited in these microfacies, and consists of burrows filled with dolomite (variety 1) and "cauliflower-like" calcite (variety 2).

Microfacies 4

Grain-supported litho-biocalcarenite with a combination of calcisilitite recrystallized to pseudospar, syntaxial overgrowths (on pelmatozoans), and void-filling sparite cement (Plate 3, G). This microfacies occurs in layers (up to approximately 7 centimeters thick) that display sharp basal contacts and a fining upward (graded) texture. The void-filling sparite occurs predominantly in the basal portion of the layers and grades upward into a matrix of well-developed pseudospar. Pelmatozoans (with syntaxial overgrowths) are the dominant bioclasts. Brachiopods, ostracods, and trilobites are the next most abundant bioclasts, plus lesser occurrences of bryozoans, gastropods, and pelecypods.

Lithoclasts, up to 1.0 centimeter and consisting of either reworked bioclasts or partially dolomitized (rhombs) calcisiltite fragments, and pellets are very abundant. Angular, silt-size quartz grains are relatively limited but St. Peter-type quartz grains reach their peak occurrence for all microfacies.

Microfacies 5

Medium to coarse, grain-supported, pelletoidal biocalcarenite with calcisiltite matrix recrystallized to pseudospar associated with sparite cement (Plate 3, H). Bioclasts are predominantly pelmatozoans, brachiopods, and ostracods, with very minor amounts of gastropods, trilobites, bryozoans, and pelecypods.

Angular, silt-size detrital quartz has a limited occurrence, as in microfacies 4. The pellets are probably fecal in origin, and are commonly deposited in thin layers which display a laminated texture when observed through a microscope.

DESCRIPTION OF DEPOSITIONAL MODELS

The deposition of the Platteville Group sequence of carbonates can be interpreted as resulting from a tripartite stratigraphic superposition of two models. Both models can be generally described as characterizing a shallow infratidal environment consisting of (in order of decreasing relative depth): calcisiltites with scattered biogenic debris; mud-supported biocalcarenites; and grain-supported biocalcarenites

TABLE 1

Average value of components by microfacies

	MICROFACIES								Grand Totals
	N-1	N-2	N-3	C-1	C-2	C-3	4	5	
Pelecypod Frequency	3.67	11.79	17.06	3.24	15.22	21.56	2.57	2.00	9.88
Gastropod Frequency	5.43	17.91	38.75	5.19	23.44	37.09	6.07	4.80	16.63
Algae Frequency	0.27	1.21	2.75	0.38	18.46	98.65	1.57	0.00	16.44
Ostracod Frequency	6.53	19.42	34.04	9.95	33.17	39.94	56.43	30.80	21.70
Trilobite Frequency	3.03	13.67	30.89	4.62	20.92	35.54	27.93	3.80	14.77
Bryozoan Frequency	1.04	5.39	16.17	2.29	10.42	13.72	13.43	2.40	6.64
Brachiopod Frequency	8.52	19.54	35.61	14.33	24.31	47.26	34.64	27.00	21.09
Pelmatozoan Frequency	8.51	23.48	56.00	13.05	34.27	66.83	153.21	41.00	31.97
Pelmatozoan Clasticity (mm)	0.49	0.74	1.13	0.41	0.72	0.83	1.02	0.40	0.67
Lithoclast Frequency	0.01	0.03	1.21	0.00	0.35	0.02	57.93	0.00	2.34
Lithoclast Clasticity (mm)	2.60	5.00	1.77	0.00	2.56	1.75	1.80	0.00	2.11
Pellet Frequency	3.75	1.00	1.54	0.00	26.78	0.00	629.29	3124.40	72.55
Pellet Clasticity (mm)	0.08	0.29	0.16	0.00	0.15	0.00	0.18	0.12	0.16
Large Quartz Frequency	0.87	3.18	1.21	0.00	0.30	3.02	6.50	0.00	1.40
Large Quartz Clasticity (mm)	0.18	0.17	0.26	0.00	0.19	0.26	0.16	0.00	0.20

with a mud matrix (Figure 5). The lower portion of the tripartite sequence has an inferred bar at the extreme left (documented by Fraser, 1974, p. 132 and 1976, p. 843), and the whole sequence (both models) has an inferred shoreline to the

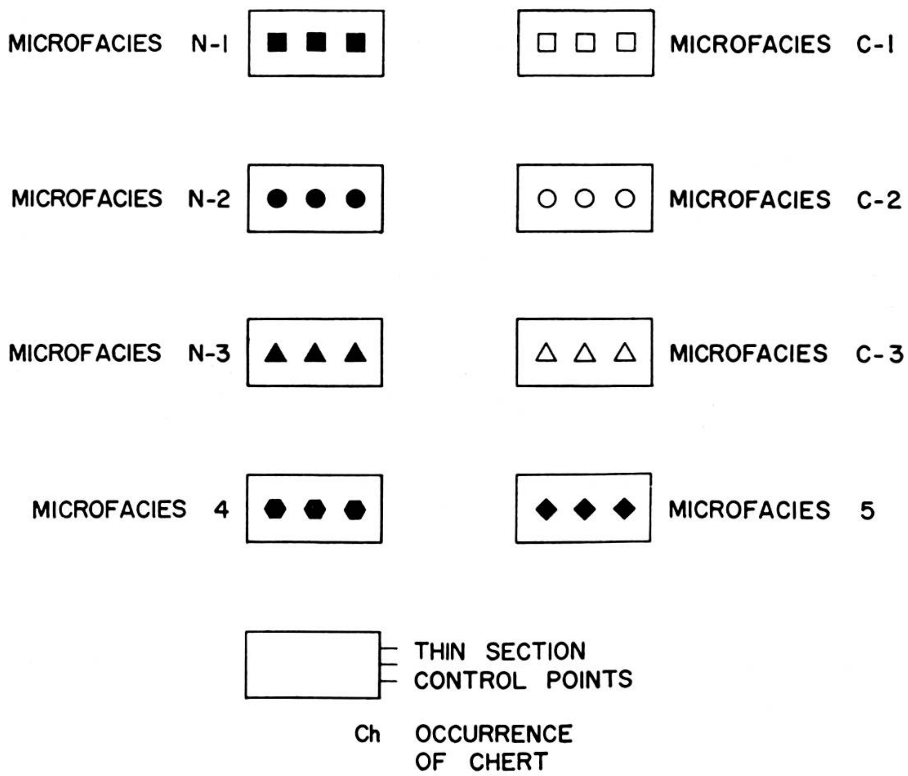

FIG. 3. — Table of symbols.

extreme right (Figure 5). The models are designated after the dominant type of bioturbation found in each: the Noncomminuted Model and the Comminuted Model. Table 2 shows Pearson correlation coefficients, based on component mean values for each microfacies, which support the noncomminuted and comminuted groupings (models) of microfacies. The correlation coefficients indicate microfacies 4 and 5 are closely related, but set well apart from the other microfacies. This supports their allochthonous nature within the two proposed models.

The variations of frequency and clasticity averages for each tabulated component in the microfacies (Table 1) composing both models were standardized (Z scores determined, as previously discussed) and are plotted below each respective microfacies (Figure 4). Microfacies 4 and 5 are not included because of their allochthonous nature in both models.

Noncomminuted model

The Noncomminuted Model occupies the lower and upper positions in the overall tripartite framework of models interpreted for the Platteville stratigraphic sequence.

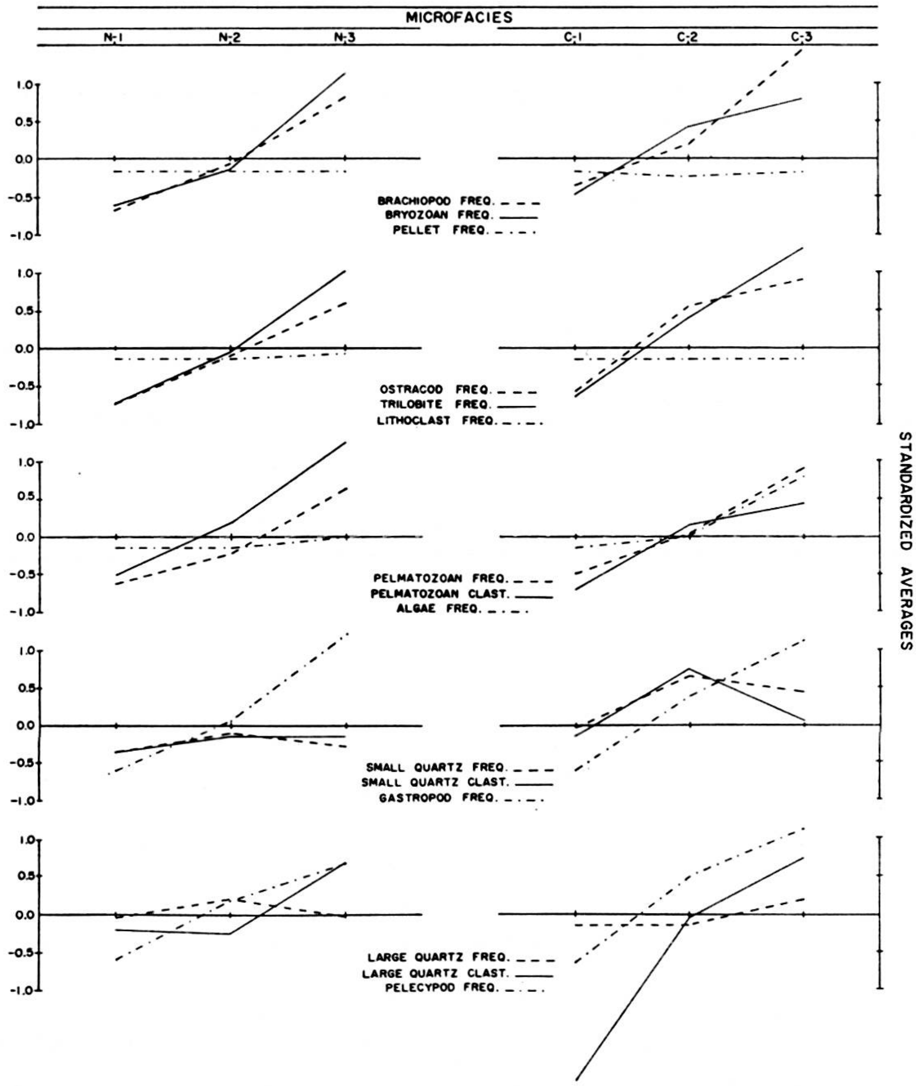

FIG. 4. — Illustration of standardized component variations of the microfacies.

TABLE 2

Correlation of microfacies by component means

MICROFACIES	N-1	N-2	N-3	C-1	C-2	C-3	4	5
N-1	1.000							
N-2	0.954	1.000						
N-3	0.590	0.559	1.000					
C-1	0.576	0.415	0.406	1.000				
C-2	0.742	0.632	0.430	0.936	1.000			
C-3	0.507	0.434	0.491	0.770	0.797	1.000		
4	−0.017	−0.109	−0.106	−0.067	−0.051	−0.149	1.000	
5	−0.078	−0.165	−0.257	−0.112	0.010	−0.212	0.972	1.000

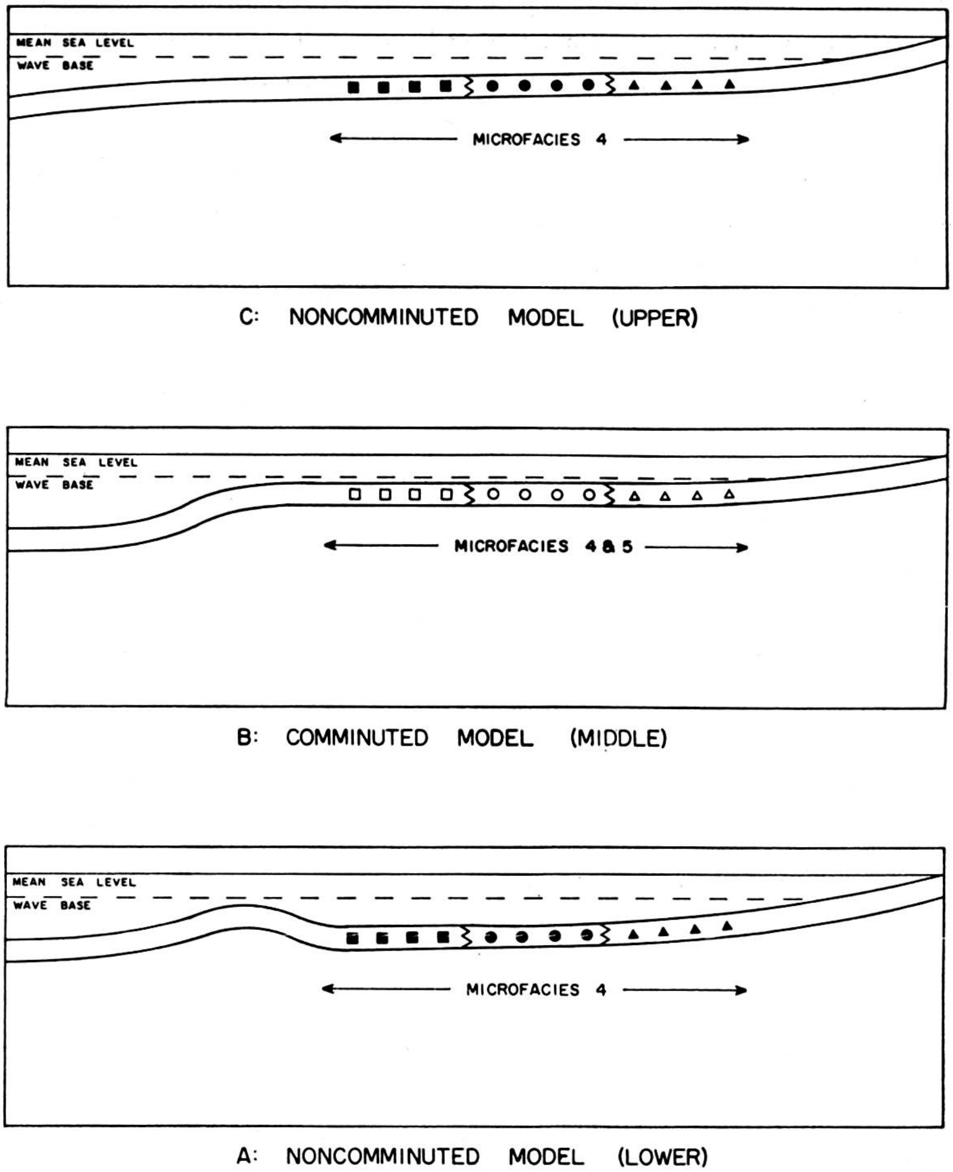

FIG. 5. — Horizontal environmental interpretation of the microfacies.

Variation of Components

All component variations described here are graphically displayed in Figure 4. Pelmatozoans, brachiopods, ostracods, gastropods, trilobites, bryozoans, and pelecypods all have below average frequencies in microfacies N-1, average frequencies in microfacies N-2, and above average frequencies for microfacies N-3. The frequency of *Vermiporella* is minimal, remaining slightly below average for microfacies N-1 and N-2 and reaching an average value in microfacies N-3.

Silt-size detrital (small) quartz is characterized by slightly below average frequencies in microfacies N-1 and N-3, and an average frequency in microfacies N-2.

The St. Peter-type (large) quartz frequencies are average for microfacies N-1 and N-3, and slightly above average in microfacies N-2. Lithoclast and pellet frequencies are minimal, being somewhat below average for all of the noncomminuted microfacies.

Pelmatozoans and silt-size detrital (small) quartz have clasticity averages that closely parallel the frequency averages for those components. Clasticity of the St. Peter-type quartz is inversely proportional to its frequency. Lithoclast and pellet clasticities for all microfacies were not standardized and plotted because of insufficient data.

Horizontal Environmental Interpretation of Microfacies

The noncomminuted sequence of microfacies represents a relatively low-energy, shallow infratidal, open marine environment that is evidenced by the diverse fauna occurring throughout the series of microfacies. The increase of biogenic component frequencies from microfacies N-1 to N-3 indicates a very gentle decrease in relative depth toward an inferred shoreline, as shown in Figure 5, A and C. The gradual increase of clasticity for silt-size detrital quartz in microfacies N-1 to N-3 also supports the gradual decrease in relative depth.

A quiet, low-energy environment is suggested by the finely crystalline calcisiltite matrix, the very limited occurrence of pellets (in burrows) and the lack of abrasion of bioclasts, as well as the preservation of delicate biogenic debris in all the microfacies.

The noncomminuted sequence of microfacies is only occasionally interrupted by microfacies 4, which results from brief, relatively high energy events. The grain-supported litho-biocalcarenites of microfacies 4 appear to be analogous to turbidites, (similar to those described by Carozzi and Frost, 1966, p. 568) but occur at a very reduced scale (a few millimeters to a few centimeters in thickness). Their source probably were adjacent elevated areas disrupted by some unknown mechanism (s) which resulted in a slurry of mud and debris flowing into adjacent areas of lower elevation. The elevated areas could have resulted from localized increases in depositional rates of biogenic debris, or unstable buildups of sediments derived from a locally exposed area. Triggering mechanisms, resulting in slumping and the above-mentioned slurry of mud and debris, could have been storms or earthquakes. Storms would temporarily extend the effective wave base down into what is normally an infratidal environment. Earthquakes can cause liquefaction in unstable (floating framework) deposits of sediments such as mud-supported biocalcarenites (microfacies N-2 and C-2).

The Noncomminuted Model occupying the basal position in the tripartite sequence of models (Figure 5, A) has an inferred submerged barrier bar located on the open marine side (extreme left) of the model. The barrier bar's presence is evidenced by the increased occurrence of microfacies 4 in the lower portion (Pecatonica

Formation) of the Troy Grove Quarry section. Fraser's study of the St. Peter-Platteville transition (1974, p. 130 and 1976, p. 843) also substantiates the occurrence of the submerged barrier bar.

COMMINUTED MODEL

The Comminuted Model occupies the middle portion of the tripartite framework of models set up for the Platteville stratigraphic sequence.

Variation of Components

The component variations discussed below are graphically illustrated in Figure 4. The biogenic components in the comminuted microfacies (C-1, C-2 and C-3) closely parallel the frequency pattern described for those components in the noncomminuted microfacies (see graphic representation of all the microfacies and their components in Figure 4). The one important exception is *Vermiporella*, which has a slightly below average to average frequency in microfacies C-1 and C-2, and increases to a high frequency in microfacies C-3.

Silt-size detrital (small) quartz frequencies are average for microfacies C-1, and well above average in microfacies C-2 and C-3. The St. Peter-type (large) quartz frequencies are slightly below average for microfacies C-1 and C-2, and increase to slightly above average in microfacies C-3. Pellet and lithoclast frequencies are minimal, as in the noncomminuted microfacies, and display below average frequencies for all the comminuted microfacies.

Pelmatozoans and silt-size detrital (small) quartz clasticity averages parallel their frequencies, as is the case in the noncomminuted microfacies. The clasticity of St. Peter-type (large) quartz generally parallels the frequency values, with the exception of microfacies C-1 where an anomalous value is produced by insufficient data.

Horizontal Environmental Interpretation of Microfacies

The comminuted sequence of microfacies very nearly parallels the noncomminuted sequence in that it also represents a relatively low-energy, shallow infratidal, open marine environment. The frequencies of the diverse biogenic components in microfacies C-1 to C-3 increase with the decrease in relative depth toward an inferred shoreline (Figure 5, B). The occurrence of *Vermiporella* as a prominent biogenic component in microfacies C-2 and C-3 suggests a very shallow infratidal environment for the Comminuted Model. The increased intensity of bioturbation and its characteristic comminuted biogenic debris, and the occurrence of a matrix of merged pellets in some thin sections also supports the shallower infratidal environment.

The minimal occurrence of pellets and lithoclasts in the comminuted microfacies indicates an overall low level of energy for the Comminuted Model, but the above average clasticities of silt-size detrital quartz in microfacies C-2 and C-3 suggest a somewhat higher energy level. The slightly higher energy level is indirectly supported by the common occurrence of microfacies 4, and the closely associated microfacies 5 (an infrequently occurring grain-supported pelletoidal biocalcarenite), in the Comminuted Model, particularly the lower portion (Mifflin Formation) of the model.

COMPARISON OF THE NONCOMMINUTED AND COMMINUTED MODELS

The Noncomminuted and Comminuted models closely parallel each other in that they both are characterized by a low-energy, relatively shallow infratidal, open marine environment with a diverse fauna. The configuration of the portion of both models directly associated with the stratigraphic sections examined in the Dixon and Troy Grove areas is generally flat and has a gentle slope due to the decrease in relative depth toward an inferred shoreline (Figure 5).The inferred portions toward the open marine side of both models are different, depending on their location in the tripartite sequence of models. The lower Noncomminuted Model is characterized by a submerged barrier bar (Figure 5, A), while the upper Noncomminuted Model displays a continuation of the flat and gently sloping configuration described above (Figure 5, C). The Comminuted Model is marked by a break in the slope, at this point, causing a slight increase in the slope of the model's configuration (Figure 5, B).

The Noncomminuted and Comminuted models have subtle but characteristic differences. The Comminuted Model occupies a somewhat higher (shallower) position in the infratidal zone than the Noncomminuted Model. Slightly higher average frequencies (associated with decrease in relative depth) are noted for the rest of the biogenic components in the comminuted microfacies. The more intense bioturbation that characterizes the Comminuted Model, by producing whorls or spiral patterns of comminuted biogenic debris (Plate 1, A), is thought to result from relatively shallower depth and related increase in bioturbating activity.

Another characteristic difference between the two models is the slight change in associated energy levels for each model. The shallower comminuted model would be expected to have a slightly higher level of energy. This assumption is supported by the higher average values of frequency and clasticity for silt-size detrital quartz in the comminuted microfacies. Also, the matrix of the Comminuted Model microfacies is generally coarser textured than the matrix of the noncomminuted microfacies.

Lastly, the grain-supported litho-biocalcarenites (microfacies 4) that disrupt both models, are much more frequent in the Comminuted Model. This indirectly suggests a shallower environment closer to effective wave base or adjacent to a coastline, based on the assumption that the turbidite-like layers (microfacies 4) are the result of either storms temporarily lowering the effective wave base of the depositional environment, or earthquakes disrupting unstable deposits of sediments adjacent to a coastline.

DESCRIPTION OF THE SECTIONS OF THE DIXON AREA

The measured sections express the detailed changes of Platteville depositional environments through time (Fig. 6 through 13) and represent the vertical variations of the previously described horizontal models. The relative depth curve, located

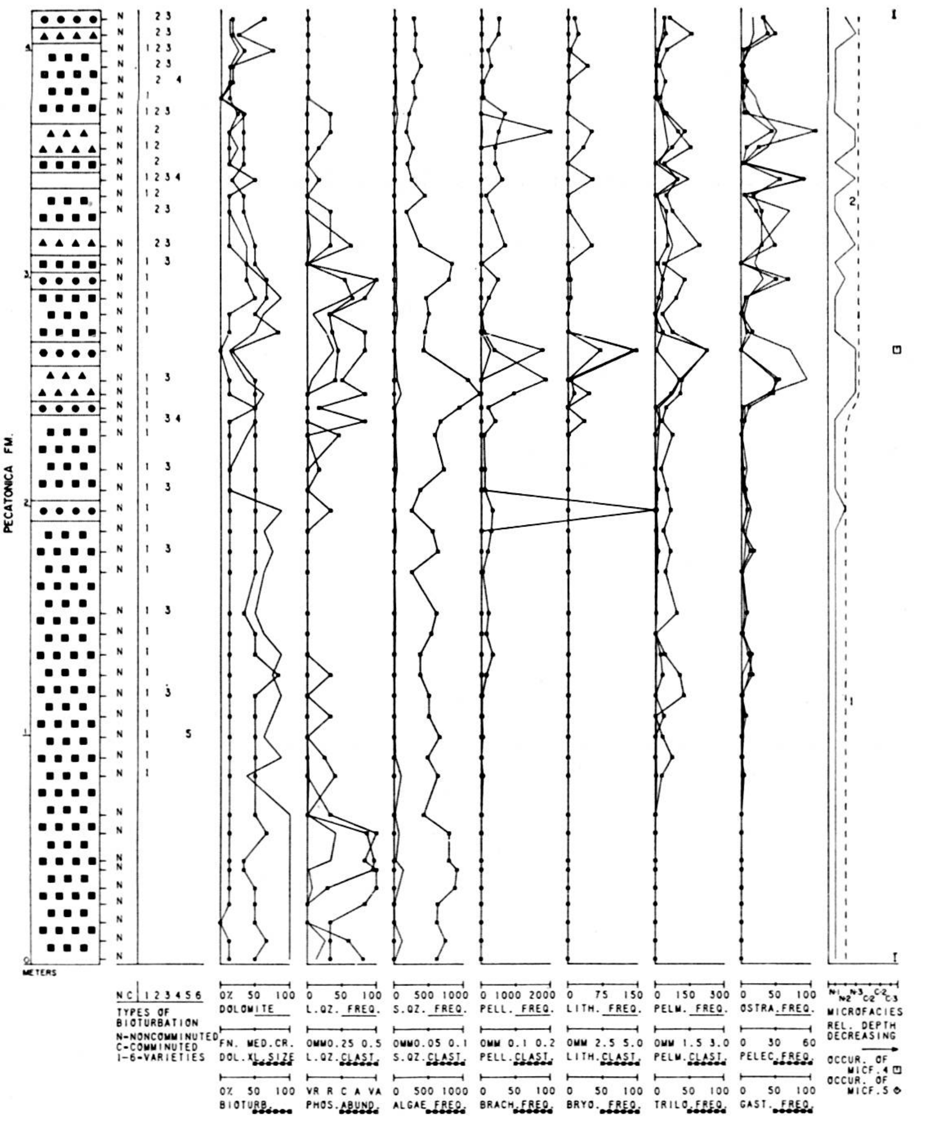

FIG. 6. — Component variations for the Medusa Northwest section.

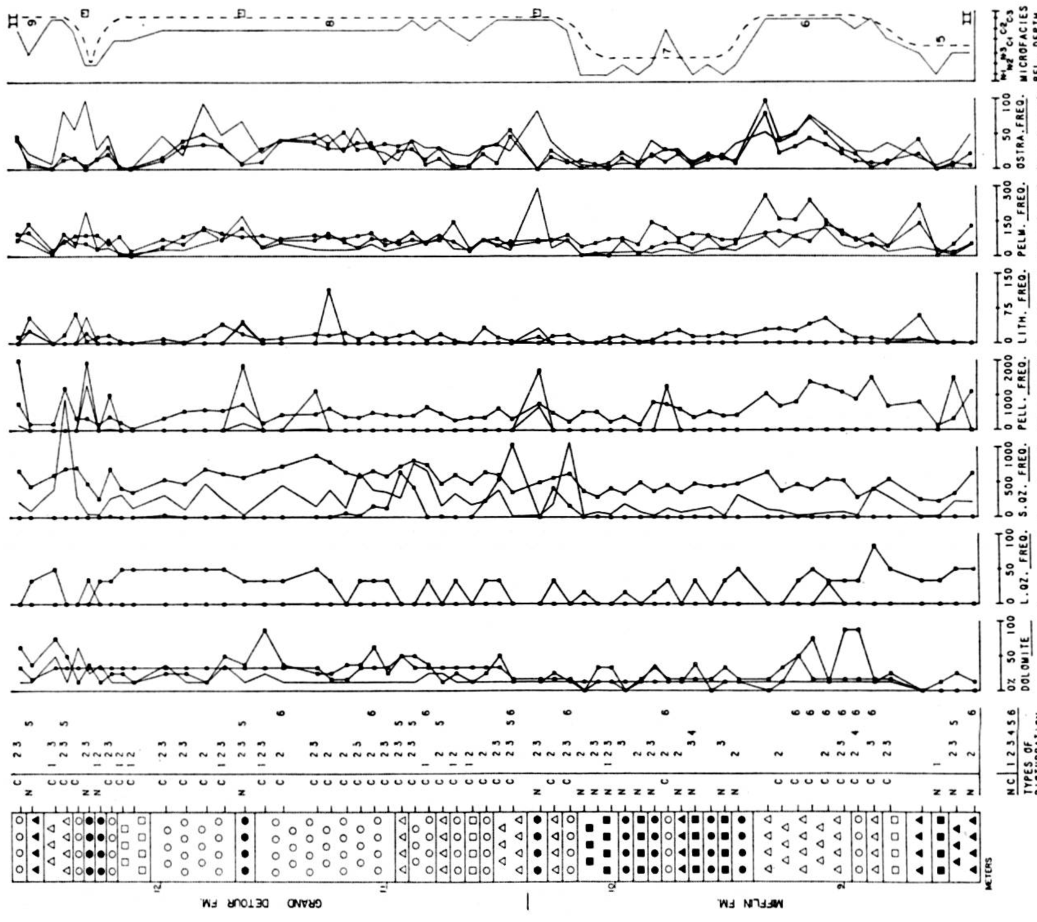

FIG. 8. — Component variations for the Medusa Northwest (continued) and Northeast sections.

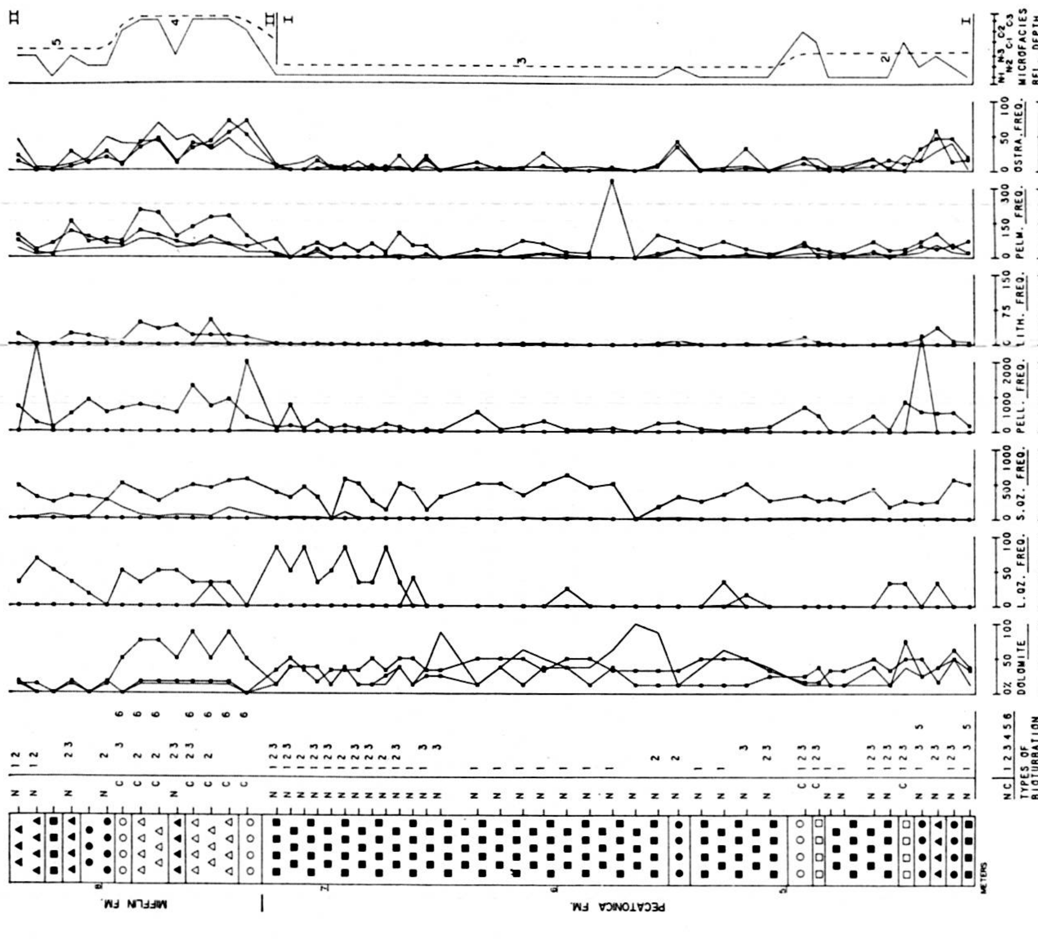

FIG. 7. — Component variations for the Medusa Northwest section (continued).

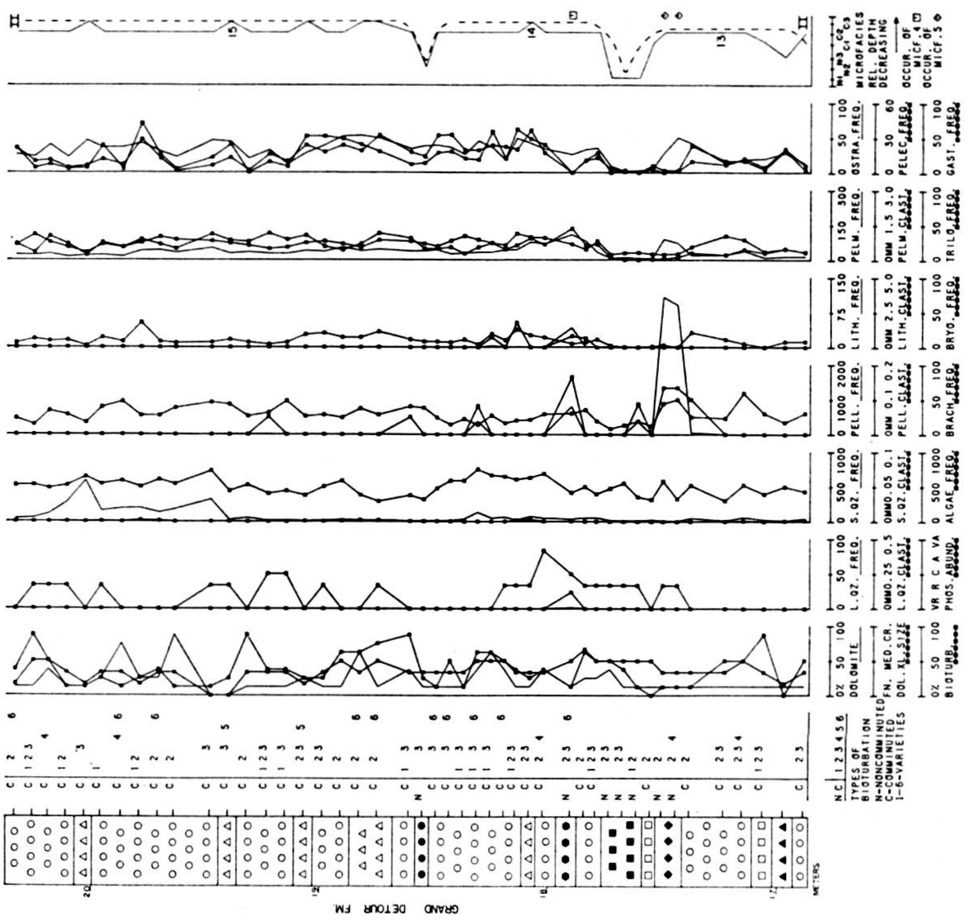

FIG. 10. — Component variations for the Medusa Northeast section (continued).

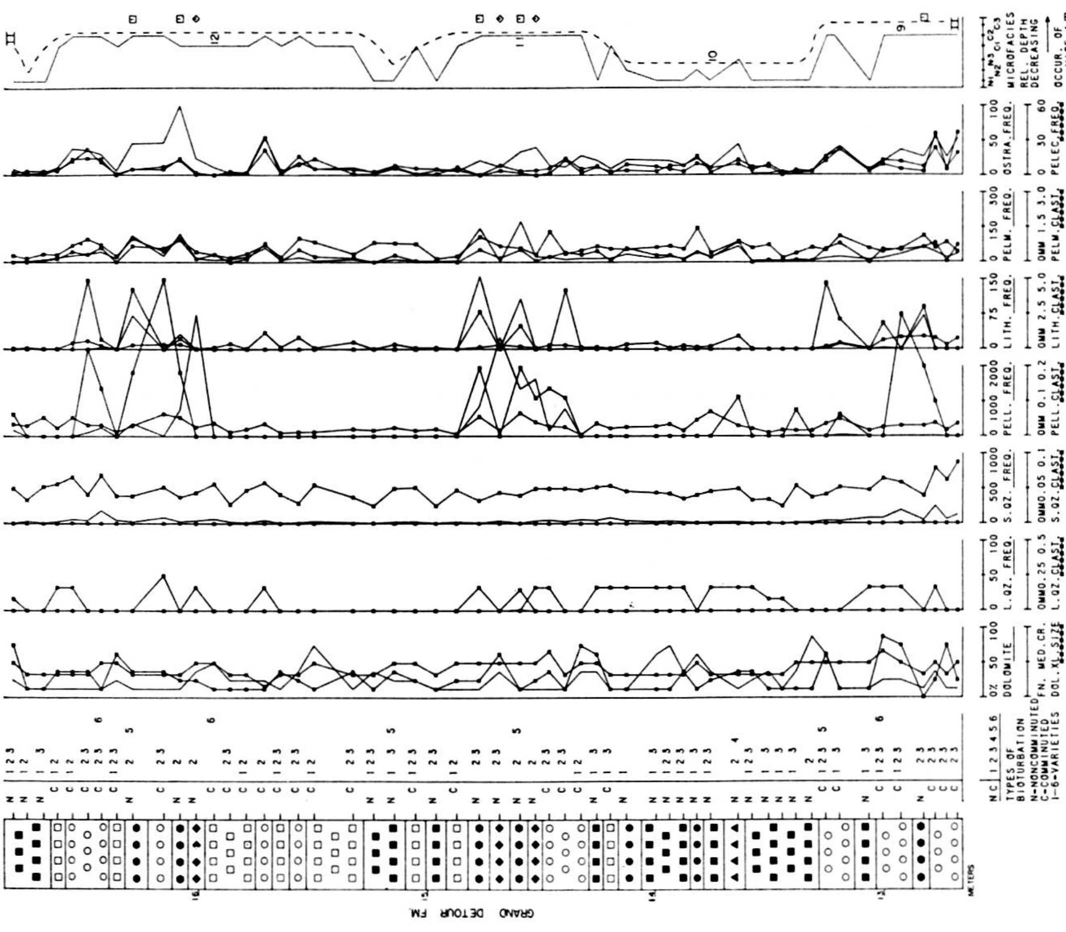

FIG. 9. — Component variations for the Medusa Northeast section (continued).

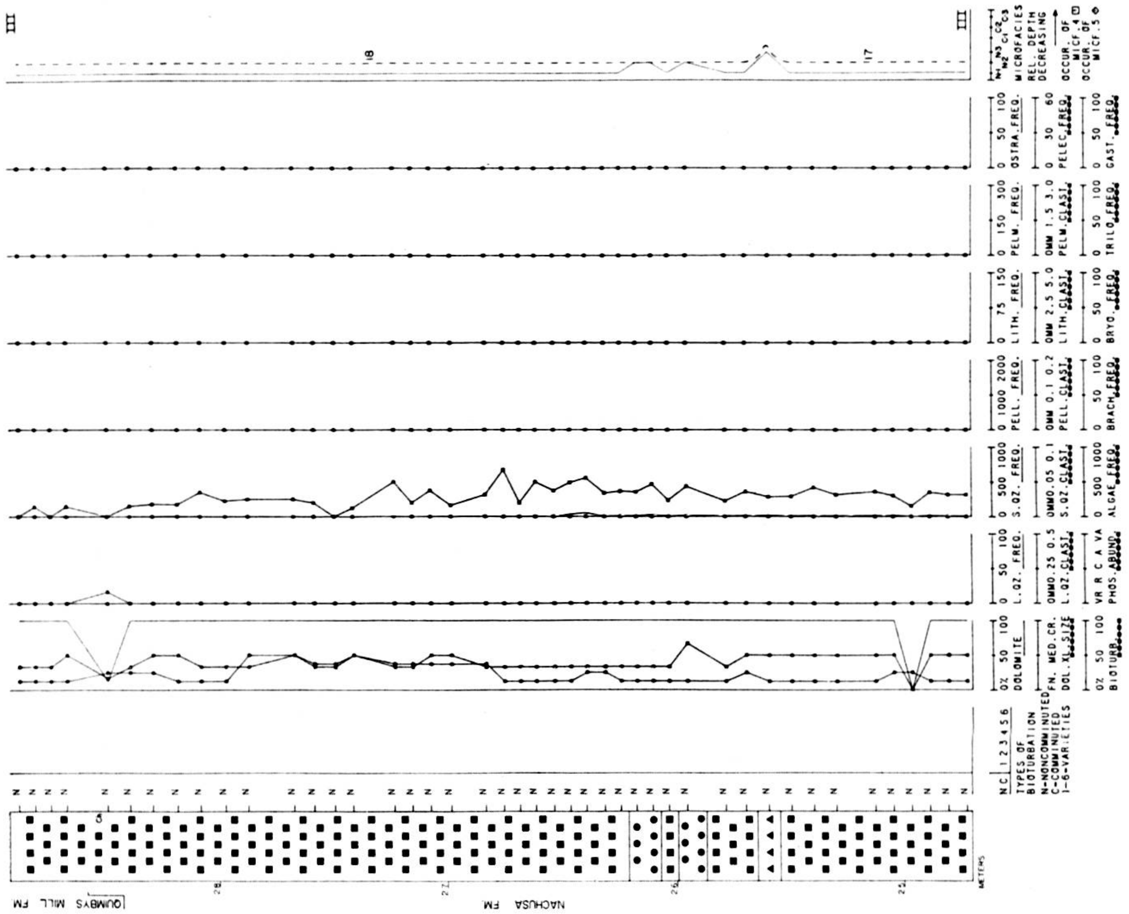

FIG. 12. — Component variations for the Dixon East (continued) and River Street sections.

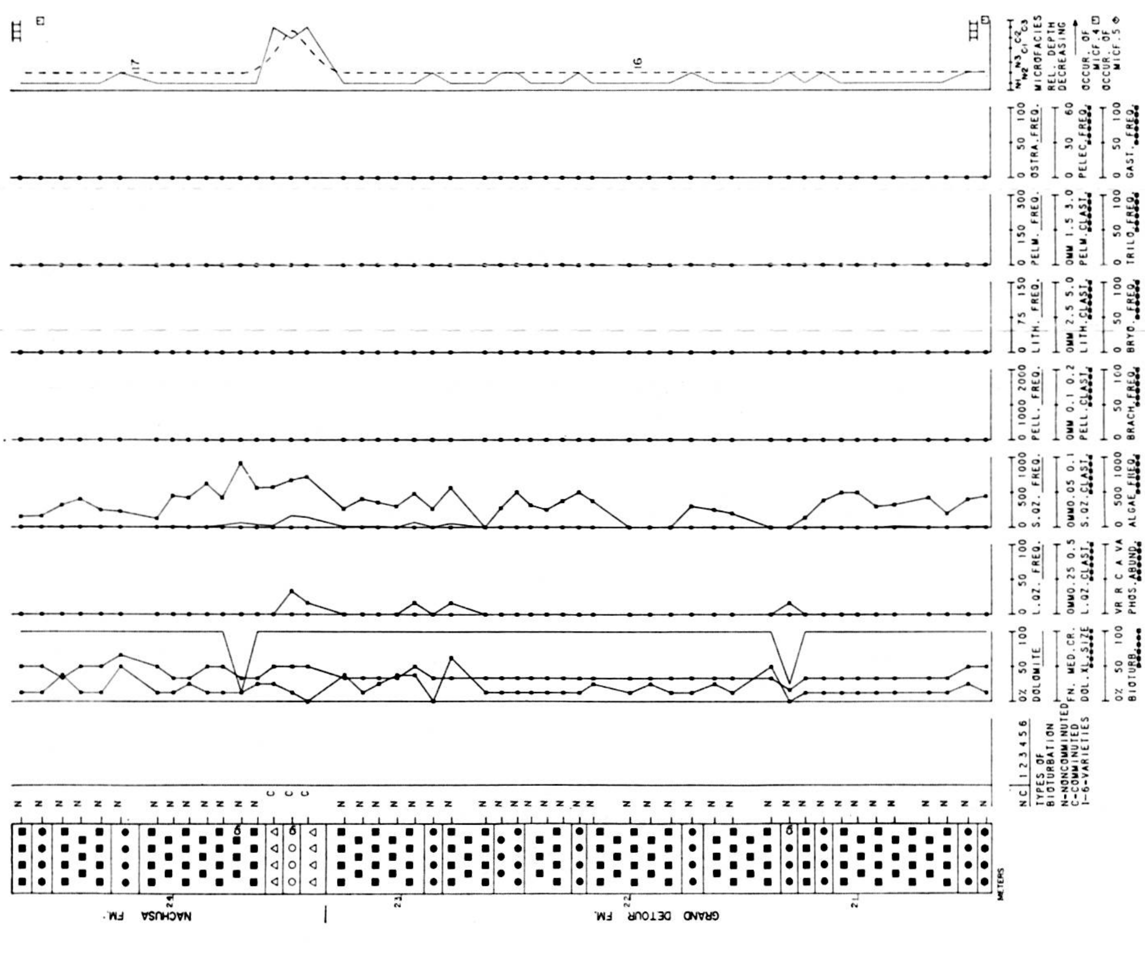

FIG. 11. — Component variations for the Dixon East section.

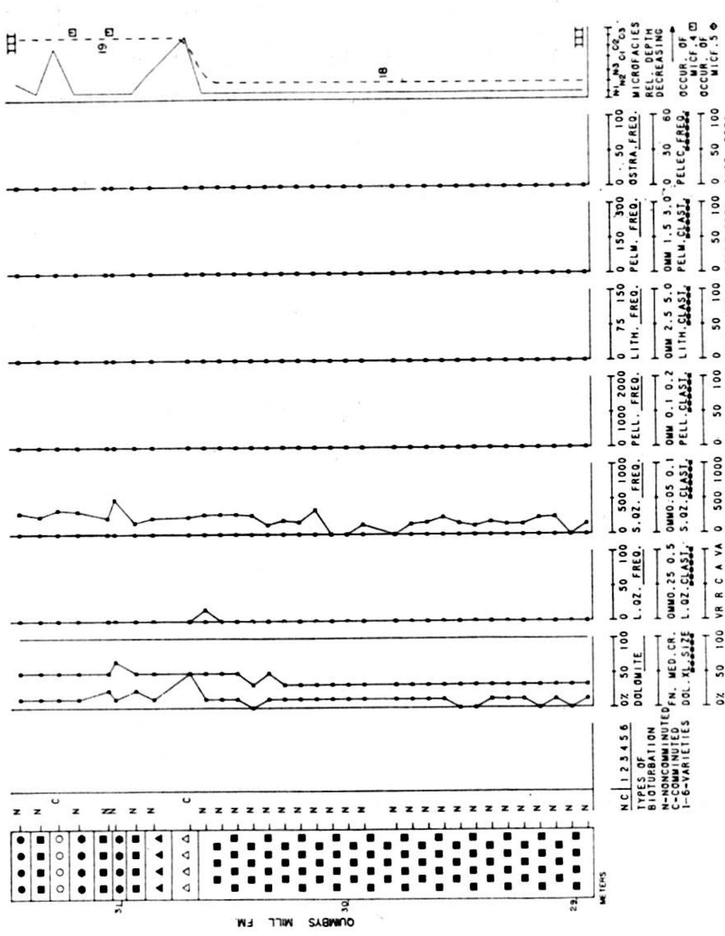

FIG. 13. — Component variations for the River Street section (continued).

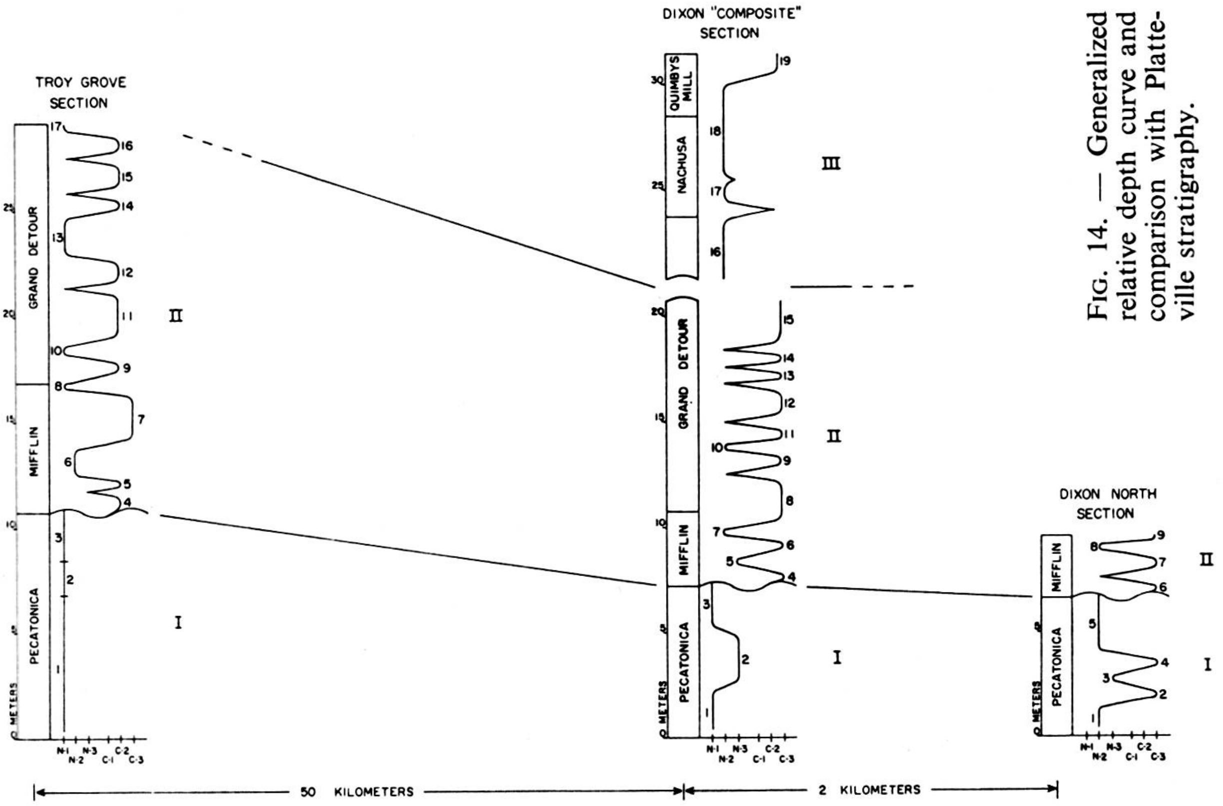

FIG. 14. — Generalized relative depth curve and comparison with Platteville stratigraphy.

at the far right is used to express the overall evolution of the depositional environment, and is based on a scale which displays the relative depths of the respective microfacies of both depositional models. The main trend of relative depth fluctuation is shown by a dashed line superimposed on the relative depth curve. The measured sections have been combined into three groups as shown in Figure 14.

Three major environment groups were found and denoted by Roman numerals. The major groups are further subdivided into smaller cycles of generally stable environmental conditions, which have been depicted by Arabic numerals at the mid-point of each cycle.

The main trend of relative depth fluctuations (Fig. 14) has been used to summarize and compare the general evolution of the depositional environments in all investigated sections.

Environmental group I

The rocks belonging to this group (Figs. 6-7) are primarily noncomminuted *calcisiltites with scattered bioclasts (cycles 1 and 3). The dominant lithology is* interrupted by noncomminuted mud-supported and grain-supported biocalcarenites (cycle 2). In general, the rocks of this group were deposited in the relatively deeper infratidal environment of the Noncomminuted Model.

Environmental group II

The rocks belonging to this group (Figs. 8-9-10) are composed of mud-supported and grain-supported comminuted biocalcarenites deposited mainly in the relatively shallow infratidal environment of the Comminuted Model. This group of rocks is subdivided into 12 cycles (4 through 15) and most of these (4, 6, 8, 9, and 11 through 15) are cycles of comminuted mud-supported and grain-supported biocalcarenites separated by brief occurrences or cycles (5, 7, and 10) of predominantly noncomminuted mud-supported biocalcarenites.

Environmental group III

Group III rocks (Figs. 11-13) are similar to the Group I rocks in that they predominantly consist of calcisiltites with scattered bioclasts, however they are completely dolomitized. These rocks are subdivided into four cycles (16 through 19) which consist of three cycles (16 through 18) of the dominant lithology and a fourth cycle (19) consisting of a comminuted grain-supported biocalcarenite marking the upper limit of the Platteville sequence. The depositional environment for this group of rocks, in general, was the somewhat deeper infratidal environment represented by the Noncomminuted Model.

COMPARISON OF STUDY WITH CURRENT STRATIGRAPHIC CLASSIFICATION

The Platteville Group carbonates are presently divided into a five formation, 24 member stratigraphic classification (Figure 2) based primarily on the relative content of argillaceous material (Templeton and Willman, 1963, pp. 63-69). Difficulties in using this classification arise from the generally homogeneous and cyclic (alternating pure and argillaceous units) nature of Platteville lithologies. Weathered surfaces are generally necessary to recognize the relative argillaceousness of the Platteville members. Because problems have arisen concerning certain members of the Platteville Group, Willman and Kolata, of the Illinois State Geological Survey, are presently carrying out a study to revise the Platteville stratigraphic classification (oral communication Kolata, 1976).

The present investigation has led to eight carbonate microfacies being defined for the Platteville sequence. The microfacies can be used to reconstruct two environmental models (generally characterized by the dominant type of bioturbation) which are combined in a vertical tripartite sequence of models.

Figure 14 shows the correlation between the proposed environmental models (and their associated major environmental groups) and the stratigraphic classification of the Platteville Group. The first major environmental group (resulting from the Noncomminuted Model) coincides with the Pecatonica Formation, and is sharply separated from the second major environmental group (resulting from the Commiminuted Model) by the diastem at the top of the Pecatonica. The second group of rocks (the Comminuted Model) is stratigraphically represented by the Mifflin Formation and nearly all of the Grand Detour Formation. The third major environmental group (the re-establishment of the Noncomminuted Model) consists of the remaining upper portion of the Grand Detour Formation, plus the Nachusa and Quimbys Mill Formations. The boundary between Group II and III is transitional.

This investigation does not appear to support the 24 Platteville members described by Templeton and Willman, even though the major environmental groups can be further subdivided into a minimum of 19 smaller zones or cycles, as shown in the Dixon "Composite" Section (Figure 14). There appears to be no clear relationship between the members in each Platteville formation (see Figure 2) and the cycles occurring in those formations (Figures 6 through 13).

CONCLUSIONS

The Platteville Group (Middle Ordovician) sequence of rocks in the Dixon and Troy Grove areas of north-central Illinois, consist of eight distinct carbonate microfacies which grade into each other (with the exception of microfacies 4 and 5) vertically and horizontally. The microfacies can be used to reconstruct two environmental models which are superposed in a tripartite sequence for the deposition of the Platteville stratigraphic interval. Both models have similar geometric configurations: consisting of an inferred shoreline, and a relatively flat and gently sloping infratidal environment that is characteristically open marine. The models differ in their general relative depths (best characterized by the dominant type of bioturbation, either noncomminuted or comminuted), and the inferred geometry for the open marine side of the models. The "Noncomminuted Model" which occupies the basal and upper positions in the tripartite sequence of models, has an inferred submerged barrier bar (toward the open marine side) for the basal model position, and just continues the above mentioned gentle infratidal slope to a deeper open marine environment for the upper model position. The "Comminuted Model" occupying the medial position, has a break in the slope (final influence of the submerged barrier bar on the depositional environment) where it increases slightly toward a deeper open marine environment.

The first six microfacies are repeated in three major depositional groups that coincide with the tripartite sequence of models, and correspond to relatively stable or characteristic patterns of relative depth fluctuation. The seventh and eight microfacies, litho-biocalcarenite and pelletoidal biocalcarenite respectively, are turbidite-like interruptions of the normal sedimentary pattern. Cyclic sedimentation is characteristic of the major depositional group associated with the Comminuted Model, while the major depositional groups coincident with the Noncomminuted Model appear more stable with minor fluctuations.

The evolution of the Platteville depositional environment (in the study areas) can be summarized by a relative depth curve which shows the tripartite sequence of: (1) a generally stable relatively deep infratidal environment (the basal noncomminuted sequence) sharply separated (diastemic boundary) from (2) a less stable (cyclic) somewhat shallower infratidal environment (the comminuted sequence) which in turn, grades into (3) a stable relatively deeper infratidal environment (upper noncomminuted sequence). The overall transgressive nature of the Platteville sequence in the study areas, was temporarily interrupted by shallowing of the seas during the deposition of the comminuted sequence. This resulted from the influence of the submerged barrier bar associated with the depositional model of the underlying noncomminuted sequence of rocks.

The basal noncomminuted sequence of rocks correlates with the Pecatonica Formation, while the overlying comminuted sequence corresponds with the Mifflin Formation and most of the Grand Detour Formation. The remaining upper portion of the Grand Detour, plus the Nachusa and Quimbys Mill Formations, coincide with the upper uncomminuted sequence of rocks. The smaller cycles or stable zones found in the three major depositional groups do not appear to correlate with Platteville members.

Petrographic evidence suggests an early post-depositional time for the major dolomitization of the Plateville sequence investigated by this study. The mechanism of dolomitization is not characterized by a restrictive environment and the associated high Mg/Ca ratios. Badiozamani's Dorag dolomitization model, or some basically similar mechanism, is the most probable source of Platteville dolomitization (in the study areas) known to date.

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PLATE I

Bioturbation Types:

A. Negative print from thin section showing noncomminuted type of bioturbation. Burrowing has not caused extensive breakage of bioclasts.

B. Negative print from thin section showing comminuted type of bioturbation where browsing organisms have produced extensive breakage of bioclasts. Much of the debris is comminuted *Vermiporella*.

Petrographic Varieties of Burrow Fillings:

C. Burrows filled with medium crystalline anhedral dolomite that is sometimes zoned (Variety 1).

D. Large burrow filled with medium to very coarsely crystalline calcite displaying distinctive "cauliflower-like" crystal aggregate. Note rim of variety 1 burrow filling (Variety 2).

E. Longitudinal section of burrow showing somewhat clearer, finely crystalline pseudospar. Zoned euhedral dolomite rhombs are scattered throughout (Variety 3).

F. Longitudinal section of burrow filled with medium crystalline sparry calcite. Burrow also contains some variety 3 pseudospar (Variety 4).

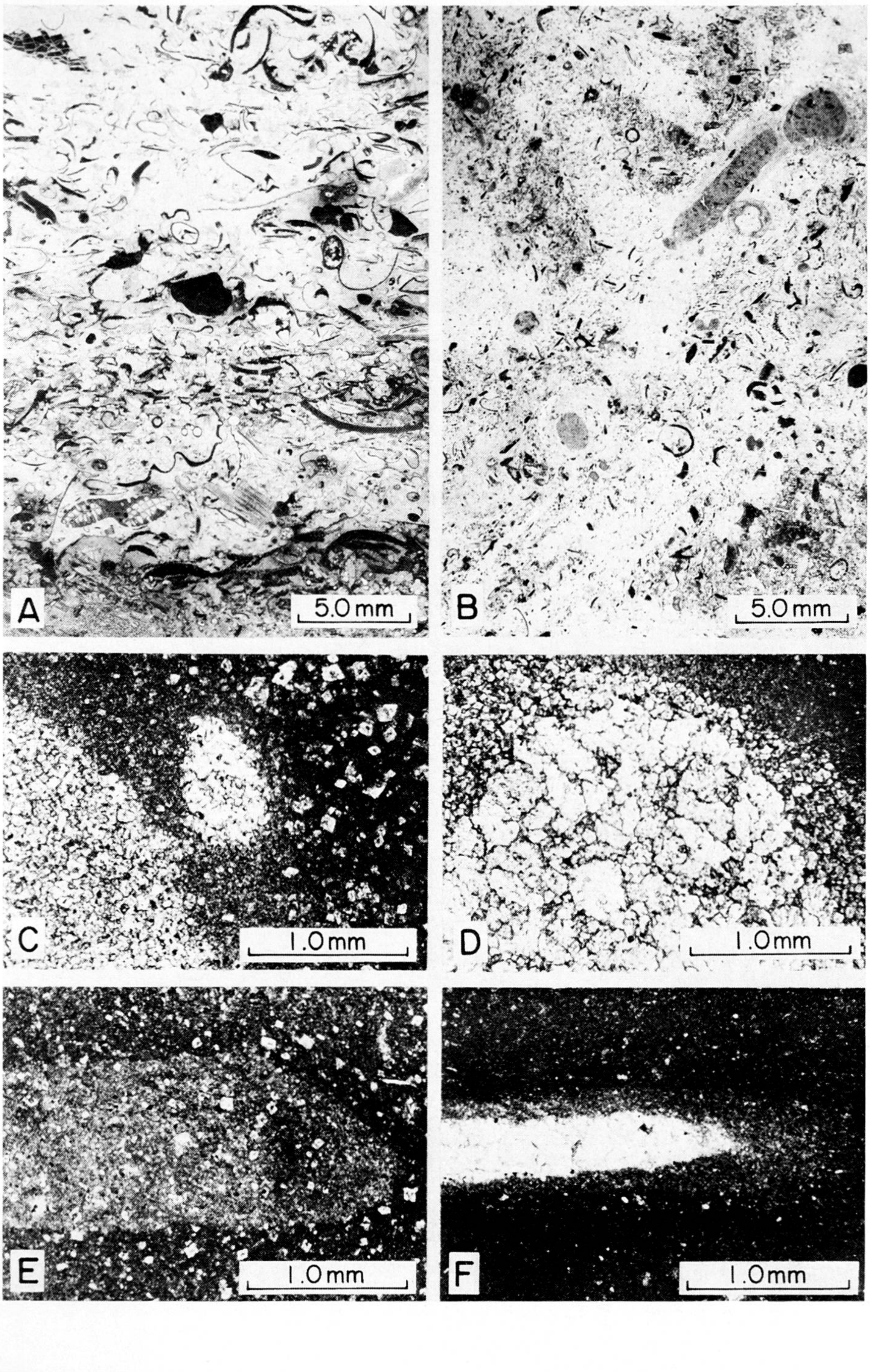
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PLATE II

Petrographic Varieties of Burrows:

A. Burrow containing biogenic debris (pelmatozoan fragments) and pellets with associated void-filling sparry calcite. The burrow is geopetal in nature and contains recrystallized calcisiltite (Variety 5).

B. Burrow wall (boundary) is marked by parallel alignment of bioclasts with interior of burrow relatively free of debris (Variety 6).

Dolomitization:

C. Even textured, fine to medium crystalline, anhedral dolomite. Well-rounded St. Peter-type quartz grains are contained in a burrow subtly delineated by a slight decrease in crystal size and increase in iron oxide and clay content.

D. Medium to coarse crystalline, subhedral dolomite. Cloudy centers of some crystals were probably pelmatozoan fragments, while the clearer areas may have been syntaxial overgrowths of pseudospar.

E. Coarse crystalline, subhedral to euhedral dolomite forming in secondary voids (moldic porosity). Crystals display cloudy centers changing to clear (limpid) dolomite toward margins.

F. Zoned euhedral dolomite rhombs commonly found in "clean" calcisiltites.

G. Well-laminated, fine to medium crystalline, anhedral dolomite associated with the Quimbys Mill Formation in the Dixon area.

H. Lithoclast, in a litho-biocalcarenite (Mifflin Formation), showing zoned euhedral dolomite rhombs truncated by the fragment's boundary indicating early post-depositional dolomitization preceding formation of the lithoclast.

PLANCHE III

Noncomminuted Microfacies:

A. Fine calcisiltite with scattered sand-size bioclasts. Note even texture of calcisiltite (Microfacies N-1).

B. Mud-supported biocalcarenite with fine calcisiltite matrix. Bioclasts are not abraded and commonly display good preservation of delicate features (Microfacies N-2).

C. Grain-supported biocalcarenite with fine calcisiltite matrix. Bioclasts are commonly very large. Note thin pyritized canals and excellent preservation of internal structure in large trilobite fragment (Microfacies N-3).

Comminuted Microfacies:

D. Fine to medium calcisiltite with scattered bioclasts. Finely comminuted biogenic debris gives calcisiltite bimodal appearance (Microfacies C-1).

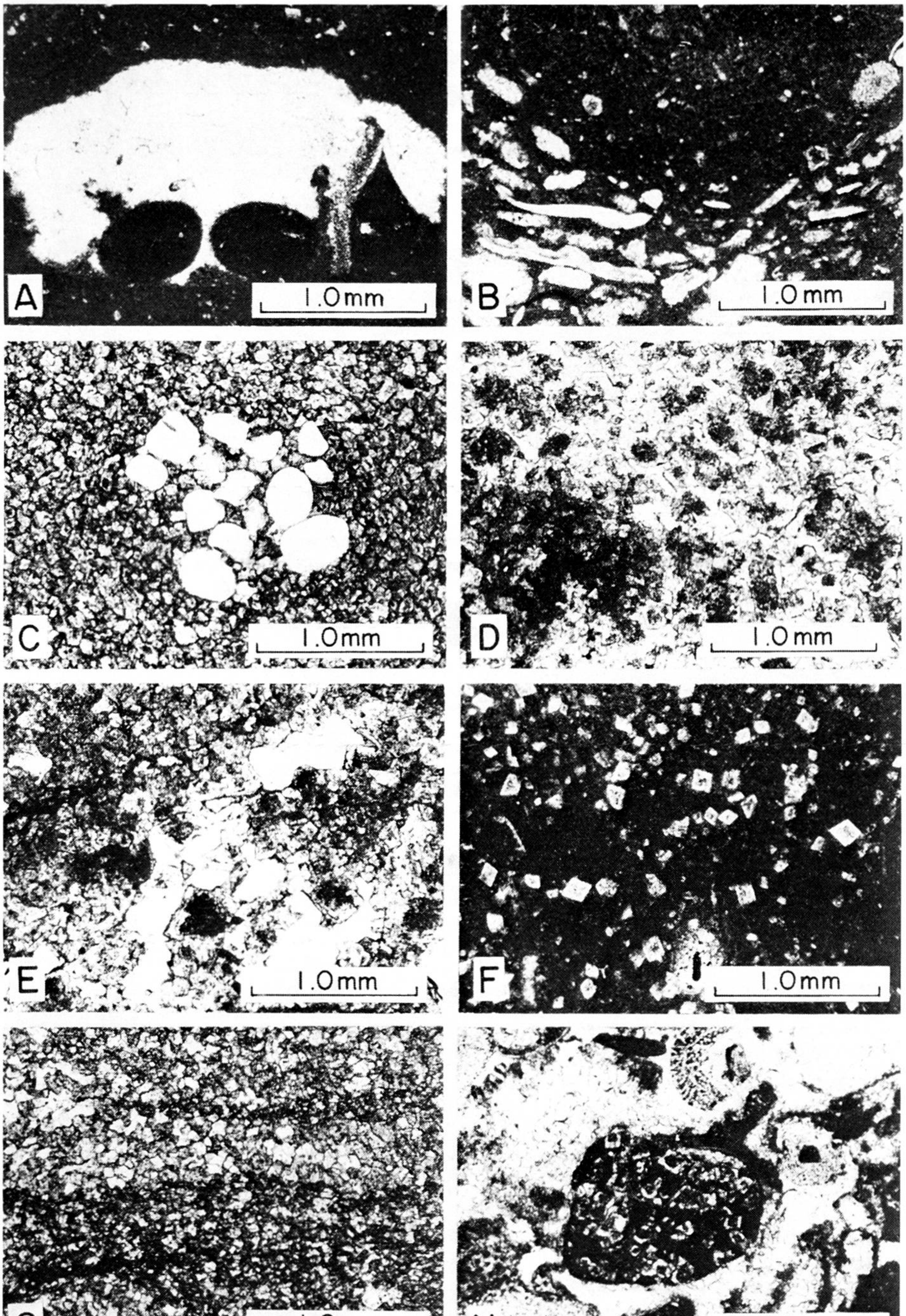
E. Mud-supported biocalcarenite with a fine to medium calcisiltite matrix. Bioclast with "figure-eight" appearance is *Vermiporella* (Microfacies C-2).

F. Grain-supported biocalcarenite with fine to medium calcisiltite matrix. Biogenic debris is thoroughly comminuted and recrystallized (Microfacies C-3).

Allochthonous Microfacies:

G. Grain-supported litho-biocalcarenite with a combination of recrystallized calcisiltite, syntaxial overgrowths, and void-filling sparite cement. Note sharp contact at base of litho-biocalcarenite, and lithoclast (Microfacies 4).

H. Medium to coarse, grain-supported, pelletoidal biocalcarenite with irregular association of recrystallized calcisiltite and sparite cement (Microfacies 5).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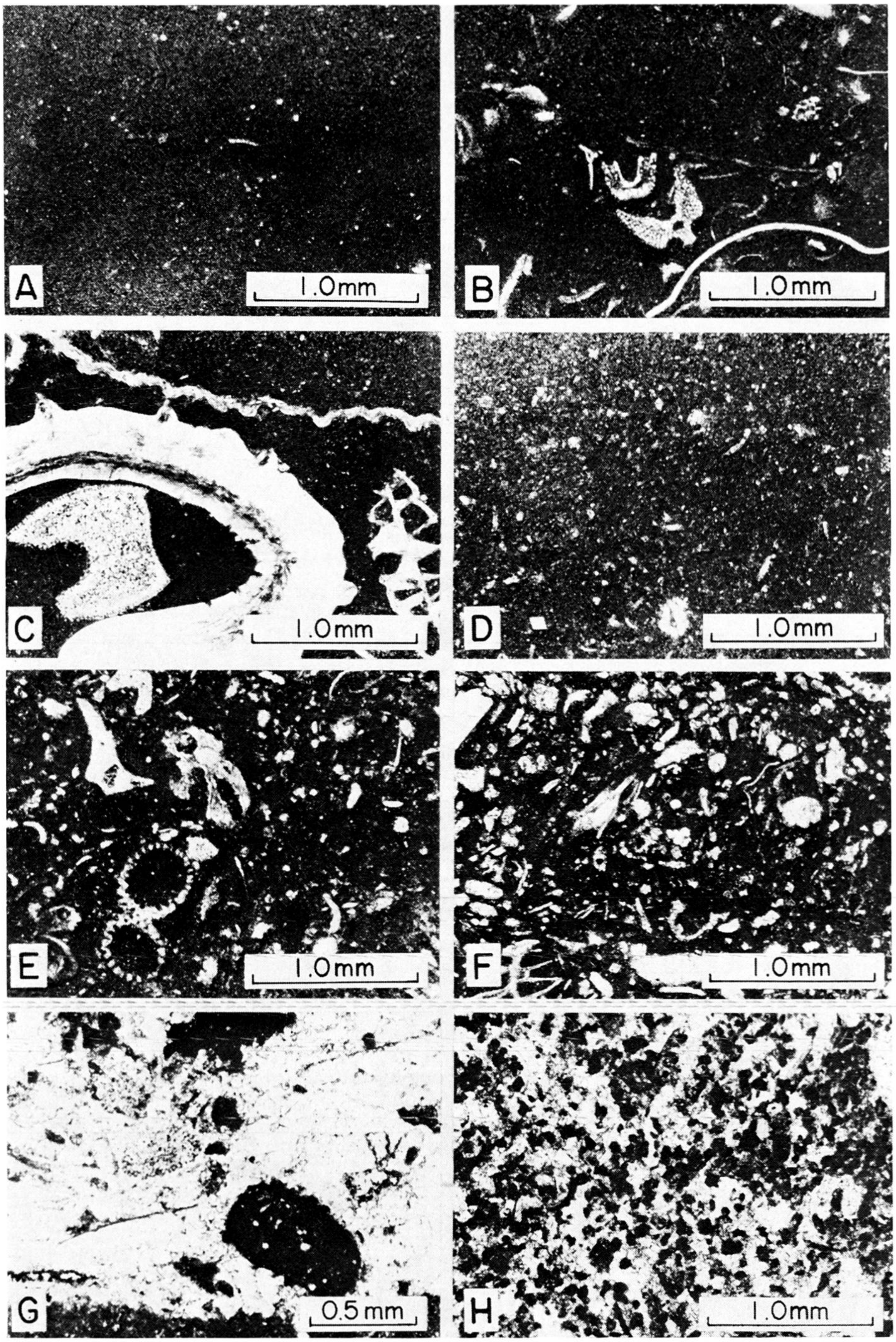
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