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SYNOPSIS: Lower Mississippian rocks in the type area of North America have produced only a few scattered ammonoid cephalopods. Those specimens from southeastern Iowa and northwestern Missouri lie within the general vicinity of the designated type locality, near Kinderhook, Illinois. In this area, age relationships for strata near the Devonian-Mississippian boundary have been established largely through studies of their conodont faunas. However, some of the ammonoids from within the Kinderhook and adjacent beds are critical for long-range correlation. Although most of these ammonoid occurrences have been recorded, minor changes in correlation can be suggested by reexamination of the specimens, together with a review of the physical stratigraphy and the associated conodont faunal data. The Kinderhookian Wassonville Member of the Hampton Formation in southeastern Iowa and the Chouteau Limestone of Missouri fall within the lower "*Pericyclus*-Stufe" of the upper Tournaisian Stage as these units are designated for the early Lower Carboniferous of Western Europe. The index genus is present, but relatively rare in North America; associated ammonoids include *Gattendorfia, Prodromites* and *Imitoceras*. All of these genera are known from the type Kinderhook area. The same genera, plus *Muensteroceras* and *Beyrichoceras* appear to characterize the overlying Osagean beds. The directly underlying Upper Devonian also contains *Imitoceras,* but *Cymaclymenia* and *Cyrtoclymenia* in addition.

INDEX DESCRIPTORS: Ammonoids, Mississippian Ammonoids.

Lower Mississippian rocks, constituting the Kinderhookian Series, have been known from the type area for 150 years. Exposures along the Mississippi bluffs at Burlington, in Des Moines County, Iowa, were used most often for reference. Meek and Worthen regarded this Iowa locality as an important section but applied the term "Kinderhook Group" in 1861 for an exposure across from Hannibal, Missouri, in Pike County, Illinois, about 75 miles south of Burlington. Those authors' assignment was a "postscript" to a discussion of age relationships and correlation for these strata. Originally, their definition included about the same stratigraphic units as are now classified as Lower Mississippian in the type area, but diverse opinions had been expressed previously and these differences persisted during the ensuing century.

Ammonoids are traditional index fossils in the Devonian and Carboniferous. However, the occurrence of cephalopods in the shelf sediments of the American Midcontinent is so sporadic that only general comparisons could be made with Europe. The known Kinderhook ammonoid fauna of seventy years ago, as recorded by Smith (1903), was as diverse and distinctive as that in other parts of the section; but a portion of these fossils is now regarded as representing the ensuing Osagean Series. That is, the abundant cephalopods secured from a thin localized carbonate layer at Rockford, Indiana, long regarded as typifying the stage, have been determined to be post-Kinderhookian (Lineback, 1963; Rexroad & Scott, 1964).

Until fairly recently, no latest Devonian ammonoids had been recognized in the Western Hemisphere, and some strata now identified as pre-Carboniferous were normally classified as part of the Kinderhookian. Sparsely fossiliferous "transition" dark shales (*e.g.* Chattanooga, Grassy Creek, etc.) were correlated with the Mississippian, because of their transgressive relationships, or mapped as "Devono-Carboniferous." As recently as twenty years ago, the stratigraphic terminology near this systemic boundary was excessively complex because of widely divergent opinion on age relationships. Meanwhile, an approved definition based upon ammonoid zonation already existed in the Sauerland of Germany, and there were substantial data on the conodont faunal sequence in various areas of the United States. The boundary at the base of the Kinderhookian could be fixed within narrow limits as soon as comparable information on conodonts became available in West Germany (Collinson, 1961). Generally, this stratigraphic determination in the Upper Mississippi Valley area was the same as that advocated by some earlier accounts, such as Branson and associates (1938), but the newer analysis was based upon more critical information. Within the past two decades, conodont studies have progressed so rapidly that these fossils now constitute standard world-wide indices (Collinson, Rexroad, and Thompson, 1971). Thus, the unexpected recognition of clymeniid cephalopods from the classic Burlington section was an important verification but somewhat anticlimactic (House, 1962). In other respects, the present study has little new to report in the fashion of Kinderhook ammonoid collections, beyond those described systematically by Miller & Collinson over twenty years ago (1951).

AGE RELATIONSHIPS

In northeastern Missouri, the Hannibal Formation may be the only widespread representation of the restricted Kinderhookian Series. In this area, it is separated by unconformities from the Upper Devonian Louisiana Limestone below, and the Osagean Burlington Limestone above (Fig. 1). In more nearly complete sections in Missouri and adjacent Illinois, the "Glen Park" Formation is found below the Hannibal Formation and the Chouteau, or equivalent, overlies it.

The Louisiana Limestone, once included within the Kinderhookian Series, has been assigned a youngest Upper Devonian age on the basis of conodonts (Ziegler, 1969). However, the Louisiana fauna is still regarded as somewhat transitional with the Mississippian (Collinson, *et al.*, 1971), and its highest portions have yielded few diagnostic conodonts, leaving the (systemic) boundary without precise faunal def-

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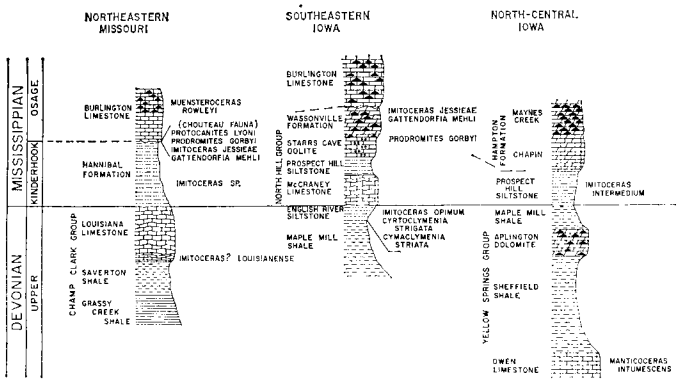

Figure 1. Diagrammatic cross section to illustrate the stratigraphic relationships and ammonoid occurrences in Lower Mississippian and Upper Devonian of the Upper Mississippi Valley.

inition in the Upper Mississippi Valley. Specimens of *Imitoceras louisianense* (Rowley) occur within the base of the Louisiana Limestone at Buffalo Creek, Pike County, Missouri. This fossil is not diagnostic but the age of the ammonoid-bearing interval is not in question, youngest Upper Devonian (Substage VI by Ziegler, 1961).

The Hannibal Formation is another unit of Kinderhookian age by definition, and it contains conodonts representing zones equivalent to basal Carboniferous (Substage I through IIα) of the European goniatite succession (Canis, 1968). A single poor specimen of the long ranging ammonoid genus *Imitoceras* found in the Hannibal Formation near Monroe City, northeastern Missouri (Miller & Collinson, 1951) has not added to existing knowledge of age relationships. However, this specimen may be the oldest known Kinderhookian ammonoid occurrence in the type region.

The Chouteau Limestone and overlying Northview Shale in central and southwestern Missouri contain an ammonoid fauna regarded as characterizing the Kinderhookian Series (Miller & Collinson, 1951). Both stratigraphic units have yielded representatives of *Imitoceras, Gattendorfia, Protocanites,* and *Prodromites,* but the Northview fauna also contains *Muensteroceras,* now considered to be only doubtfully present in the Chouteau. These ammonoid genera, except *Muensteroceras,* range from basal Kinderhookian into basal Osagean strata elsewhere, and do not provide a means for precise age assignment. *Muensteroceras* characterizes Osagean faunas, but initially appears in strata of upper Kinderhookian age. On the basis of conodonts, the combined Chouteau and Northview appear to be entirely upper Kinderhookian in age, equivalent to cuIIα zone faunas of the European goniatite succession (Canis, 1968; Thompson & Fellows, 1970). Unfortunately, the ammonoid occurrences cannot be related precisely to these recent investigations of conodonts. However, this conodont correlation suggests that there are no North American ammonoid faunas of cuI age known at the present time, except for the immature specimens in the upper portion of the Exshaw Formation of Alberta (Schindewolf, 1959).

In northeastern Missouri, the Burlington Limestone represents basal Osagean Series, in those areas where the Meppen and Fern Glen Formations are absent. Although Burlington ammonoids are extremely rare, a few specimens representing *Muensteroceras rowleyi* Miller & Furnish have been recovered from near Louisiana, Missouri. The Burlington Limestone contains representations of conodont zones which are equivalent to the upper part of the European *Scaliognathus anchoralis* zone (cuII$\beta\gamma$) on the authority of Collinson, *et al.* (1971).

The Wassonville Formation has produced all the Kinderhookian ammonoids known from southeastern Iowa (Fig. 1). At its type locality on the English River in Washington County, a fauna representing two species and more than a dozen specimens has been recovered from chert nodules in the upper part of the Wassonville, near the unconformable contact with Burlington. These two species represent *Imitoceras jessieae* (Miller & Gurley) and *Gattendorfia mehli* Miller & Collinson, both originally described from the Chouteau Limestone. In addition, a single specimen of *Prodromites gorbyi* (Miller) has been found at the base of the Wassonville Formation in Burlington. Based upon conodonts, the Wassonville Formation throughout its entire extent falls within the *Siphonodella isosticha-S. cooperi* assemblage zone of the Upper Mississippi Valley (Straka, 1968). This zone correlates with cuIIα of the European Lower Carboniferous. Consequently, the Wassonville Formation, largely dolomite, is generally understood to be a direct equivalent of the Chouteau Limestone in Missouri.

Clymeniid ammonoids representing *Cyrtoclymenia strigata* House and *Cymaclymenia striata* (Münster) are associated with *Imitoceras opimum* (White & Whitfield), in the uppermost English River Siltstone at Burlington, the "*Chonopectus* Sandstone" of Weller (1900). Use of the name English River for these strata at Burlington has been questioned by Straka (1968) because both the ammonoids and conodonts recovered from this interval indicate an Upper Devonian age (to V-VI) whereas the type English River in Washington County, is of Mississippian age (cuI). The beds called English River at Burlington, although in continuity with that formation represent siltstones stratigraphically equivalent to the upper Maple Mill Shale.

A single exposure along Beaver Creek, near Ackley, north-central Iowa has yielded several globose ammonoids referred to *Imitoceras intermedium* Schindewolf (Fig. 1). Age and stratigraphic assignment of this horizon have been controversial (Stainbrook, 1950). Since the occurrence of *I. intermedium* transgresses the Devonian-Carboniferous boundary in Europe (Schindewolf, 1923), its occurrence adds little information to the solution of this problem in north-central Iowa. Anderson (1969) has assigned the locality to the Prospect Hill Siltstone of Kinderhookian age, based on the occurrence of *Siphonodella quadruplicata* (Branson & Mehl). Therefore, this ammonoid-bearing horizon correlates with the lower portion of the Chouteau Limestone (Canis, 1968), equivalent to cuIIα of the European goniatite succession.

The concept of a Kinderhookian ammonoid fauna has been based primarily on the Chouteau and Rockford, Indiana, occurrences. However, the Chouteau fauna is now believed to lack the characteristic Rockford ammonoid *Muensteroceras.* On the basis of conodonts the Chouteau can be restricted to a late Kinderhookian (=*Pericyclus* Stufe, cuIIα) age (Canis, 1968). The Northview Shale, also of late Kinderhookian age, contains *Muensteroceras* at King Butte, Greene County, southwestern Missouri, but there is no associated conodont

information from this locality. The classic Indiana Rockford ammonoid fauna is now thought to be restricted to basal Osagean Series; associated conodonts confirm an earlier suggestion by Lineback (1963). In addition, the "Walls Ferry" (=St. Joe) fauna described by Gordon (1965) from northern Arkansas contains ammonoid genera represented in both the Chouteau and Rockford faunas including *Protocanites lyoni* (Meek & Worthen). This Arkansas occurrence has also been shown to be associated with a basal Osagean conodont fauna (Thompson & Fellows, 1970). Consequently, the Kinderhookian fauna has somewhat changed its identity, for such characteristic species as *Protocanites lyoni* and *Prodromites gorbyi*, previously thought to be restricted to Kinderhookian strata, now are known to range into the Osage.

The only other North American Lower Mississippian ammonoid occurrences, which contain genera in common with faunas of the type region, still lack associated conodont information. The Coldwater Shale-Marshall Sandstone fauna from Michigan is enigmatic and possibly mixed, but it is undoubtedly Osagean in age because of the occurrence of *Merocanites* and *Beyrichoceras* (Miller & Garner, 1955). However, the Marshall also contains representatives of the older genera *Kazakhstania* and *Gattendorfia*, not known to range into Osagean or equivalent strata elsewhere. Similarly, the upper Cuyahoga-Logan ammonoid fauna from Ohio includes representatives of *Imitoceras, Gattendorfia, Muensteroceras,* and *Protocanites* found in type Kinderhookian occurrences (Manger, 1971). In addition the Ohio strata contain *Kazakhstania* and *Karagandoceras*. This interval is thought to be late Kinderhookian in age, because of the association of *Gattendorfia* and *Protocanites* with older forms such as *Karagandoceras* and *Kazakhstania*. However, recent revisions in ammonoid ranges based on associated conodonts suggest that this fauna could possibly be of basal Osagean age.

In summary, all ammonoid occurrences in the type region appear to be late Kinderhookian (=*Pericyclus* Stufe cuIIα) in age on the basis of associated conodonts. Although a single Hannibal specimen may be older, it cannot be related to conodont occurrences at the present time. Thus, there are no early Kinderhookian (=*Gattendorfia* Stufe cuI) ammonoids known from the type region. In addition, there appear to be no other early Kinderhookian faunas known elsewhere from North America, with the exception of those from the Exshaw Formation of Alberta. Finally, the late Kinderhookian ammonoid fauna consists of long-ranging genera and lacks sufficient identity to define the Kinderhookian-Osagean boundary.

ACKNOWLEDGMENTS

This Kinderhook ammonoid project was suggested by Harrell L. Strimple, who contributed materials and helped with advice. It should also be recognized that a comprehensive survey of most of these fossils by A. K. Miller and Charles Collinson was published in 1951; so we have largely relied on their data and merely reviewed it in terms of present stratigraphic and taxonomic concepts. Additional materials came from the John B. Owen and the Merrill A. Stainbrook Collections, at the University of Iowa. Particularly, we wish to acknowledge Gilbert Klapper for advising us regarding current research and conclusions based upon significant conodont studies. Also, Jürgen Kullman has given us the benefit of his knowledge concerning details of European ammonoid species near the Devonian Carboniferous boundary. Northeastern University partially defrayed travel expenses for Manger during preparation of the study, and the University of Iowa provided laboratory facilities.

SYSTEMATICS

Genus *Gattendorfia* Schindewolf, 1920

Type species: *Goniatites subinvolutus* Münster, 1839; O.D.

An ammonoid associated with *Imitoceras* and with basically the same simple suture pattern is distinguished by more open coiling in the mature stage of growth. The characteristic whorl section in *Gattendorfia* also shows a distinct umbilical shoulder and a pronounced umbilical wall with the umbilical lobe centered on this portion of the conch. In gross external features, the shell of *Gattendorfia* thus resembles *Muensteroceras* Hyatt and also *Pericyclus* Mojsisovics, early goniatitids with a divided ventral lobe.

Schindewolf's genus typifies the *Gattendorfia*-Stufe or lower Tournaisian (lowermost Carboniferous) of the Rhenish Highlands area, but does occur in younger strata. Miller & Youngquist (1947) were apparently the first to recognize the genus in North America. They described a fairly typical-appearing representative of the genus, *G. bransoni*, from the Caballero Formation of New Mexico. Nevertheless, some doubt still exists concerning generic assignment, for the undivided ventral lobe has not yet been substantiated in that species, while the goniatitid *Muensteroceras* is known to occur in the same fauna. *Gattendorfia* is a rare but characteristic ammonoid of the Chouteau Limestone in the type Kinderhook region; but no certain true goniatitids, such as *Muensteroceras*, have been found associated there—a possible exception exists in *Muensteroceras osagense* (Swallow), as interpreted by Smith, 1903. At Rockford, Indiana, *Muensteroceras* is abundant, but there are no representatives of *Gattendorfia*; the older "Rockford" of northern Indiana described by Gutschick & Treckman (1957) has the Chouteau ammonoid fauna. Similarly, in southwestern Missouri, the late Kinderhook Northview Siltstone and Shale carries *Muensteroceras* but apparently no true *Gattendorfia*. Thus, it seems that there is a consistent zonal relationship and a sequential occurrence for these two similar-appearing genera. Nevertheless, in the Marshall Sandstone of Michigan (Miller & Garner, 1955) and in the upper Cuyahoga-lower Logan Formations of Ohio (Manger, 1971) the two genera are found in direct association. Other records are somewhat uncertain; *e.g. Gattendorfia* spp. (Gordon, 1965) of the "Walls Ferry Limestone" (=St. Joe Limestone according to Thompson & Fellows, 1970) in northern Arkansas presumably represent *Muensteroceras* in an immature stage.

Gattendorfia mehli Miller & Collinson, 1951

Pl. 1, figs. 1, 2.

Gattendorfia mehli MILLER & COLLINSON, 1951, Jour. Paleontology, 25(4), 469-470, pl. 70, fig. 11

Muensteroceras? spp. [part] MILLER & COLLINSON, 1951, Ibid., 474, pl. 69, figs. 3, 4 [not Pl. 68, figs. 12, 13].

The taxon designated *Gattendorfia mehli* was based upon a single large compressed specimen from the lower Chouteau Limestone in central Missouri. Additional smaller specimens from the same general level and locality referred to *Muensteroceras?* spp. by Miller & Collinson (1951) are, in part at least, to be associated with *G. mehli*. The single specimen those authors identified as *G.* aff. *bransoni* is fractured and

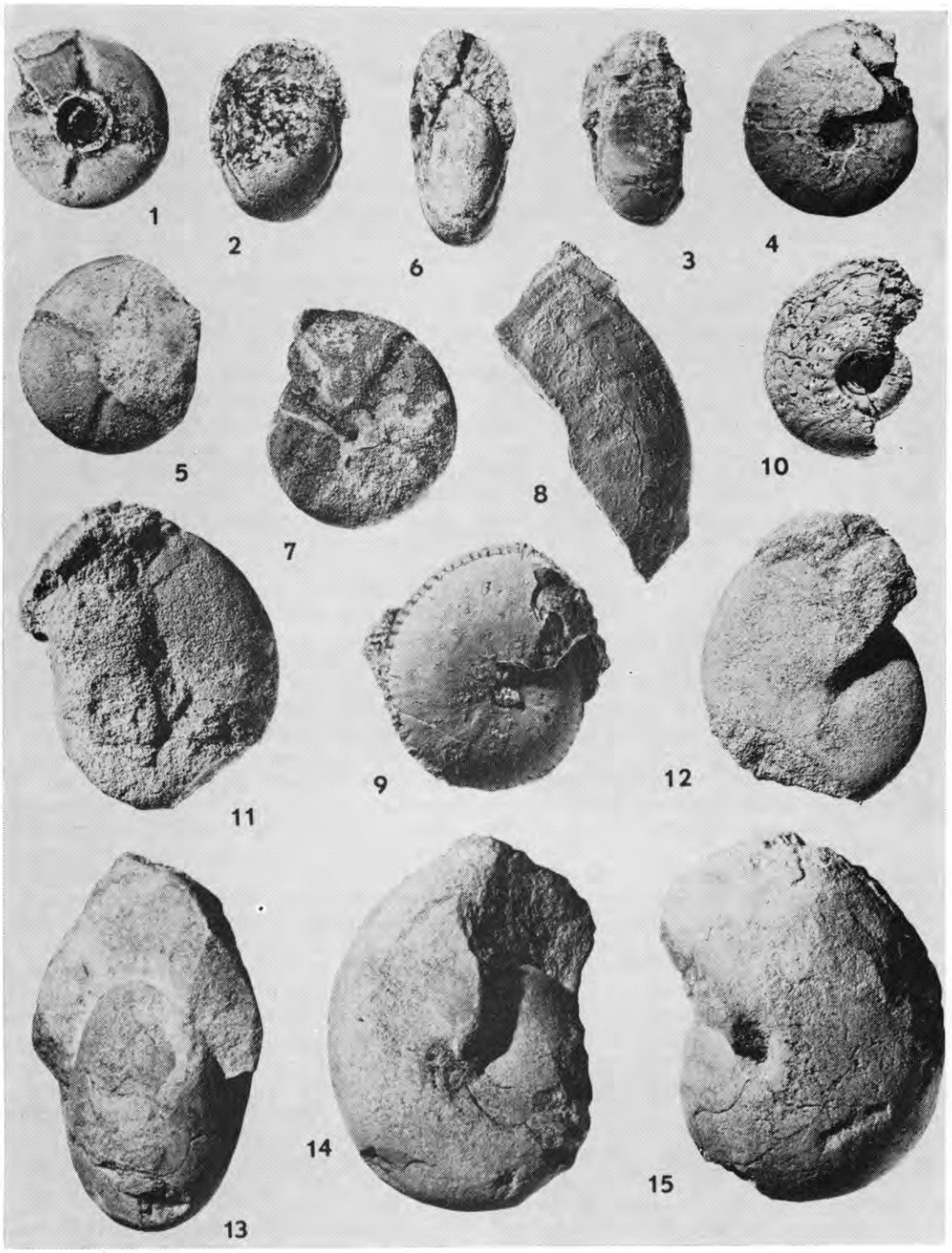

Plate I

Figures 1, 2. *Gattendorfia mehli* Miller & Collinson? Hypotype (SUI 6799), X2, type Wassonville Dolomite, Washington County, southeastern Iowa.
Figures 3, 4. *Muensteroceras medium* Miller & Collinson. Holotype (SUI 6798), X1.4, Northview Shale at Kings Butte, Greene County, southwestern Missouri.
Figures 5-7. *Imitoceras jessieae* (Miller & Gurley). Fig. 5, hypotype (SUI 13972), X1.6; fig. 6, 7, hypotype (SUI 6792) X1.4, type Wassonville Dolomite.
Figures 8-10. *Prodromites gorbyi* (Miller). Fig. 8, hypotype (SUI 13927), X1, Chouteau Limestone north of Sedalia, Pettis County, central Missouri—with a fragment of the angular keel visible in the uppermost part of the figure; fig. 9, hypotype (SUI 13929), X1.8, same locality; fig. 10, hypotype (SUI 9549), X1.8, Northview Shale near Northview in Webster County, Missouri.
Figures 11-15. *Imitoceras intermedium* Schindewolf. Fig. 11, 12, hypotype (SUI 11511), X1.4; fig. 13-15, hypotype (SUI 37058), X1, Prospect Hill Siltstone in Butler County, east of Ackley, north-central Iowa.

distorted but seems to be more globular and widely umbilicate than *G. mehli;* sutures of the two are similiar. Another Kinderhook ammonoid involved in this group of specimens is from weathered chert of the Wassonville Dolomite in southeastern Iowa. The Iowa specimen (Pl. 1, figs. 1, 2) is small and does not retain a trace of the sutures, but the conch form resembles the Chouteau *Gattendorfia* specimens, rather than the associated *Imitoceras* or comparably sized representatives of *Muensteroceras.*

Gattendorfia occurs in Ohio and Michigan as *G. andrewsi* and *G. ohiensis* of Winchell (1870) and *G. stummi* Miller & Garner, 1955. The last species, from the Marshall Sandstone certainly represents a post-Kinderhook age, because of *Muensteroceras, Beyrichoceras,* and *Merocanites* in association. Nevertheless, these three designated species from Ohio-Michigan and *G. mehli* from Missouri are closely similar.

Genus *Imitoceras* Schindewolf, 1923

Type species: *Ammonites rotatorius* deKoninck, 1844; SD Schindewolf, 1926, Senckenbergiana 8(2), 70.

There are still problems in generic assignments within the group of Upper Devonian and Lower Mississippian ammonoids usually identified as *Imitoceras.* Briefly, the procedures suggested by Vöhringer (1960) appear to be most appropriate in a definition of Schindewolf's genus. Petter (1959) has recommended a wider meaning for *Prionoceras* Hyatt, 1883, and Kullman (1961) treats *Imitoceras* as a subgenus of *Prionoceras.* That genus, normally, can be relegated to the middle Upper Devonian and typically occurs in the *Prolobites-Platyclymenia* Stufe (to III-IV) in Europe. There are consistent differences in the shell form that can be used to distinguish *Imitoceras* typically found in lower *Pericyclus*-Stufe (cuII∝) of the Lower Carboniferous; although exact limits between the two genera are obscure. As defined, *Imitoceras* has been found to occur within both Upper Devonian and Lower Mississippian strata of America, and is widely distributed elsewhere.

Several forms referable to *Imitoceras* in the Upper Mississippi Valley region have been described and illustrated by Miller & Collinson (1951). The six species that these authors identified, mostly in central and southern Missouri, are probably not recognizable in a practical sense. Still, detailed species differentiation is traditional for this group, and Vöhringer (1960) listed 22 comparable taxa in the Sauerland.

Imitoceras louisianense (Rowley, 1895)

Goniatites louisianensis ROWLEY, 1895, Amer. Geologist, 16, 221, figs.; 1908, Mo. Bur. Geol.-Mines, ser. 2, 8, 93, pl. 19, figs. 26, 27.
Prolecanites louisianensis (Rowley) SMITH, 1903, U.S. Geol. Survey Mon. 42, 54, pl. 6, figs. 6-8.
Protocanites louisianensis (Rowley) SCHMIDT, 1925, Preuss. Geol. Landesanst. Jahrb. 45, 537; WILLIAMS, 1943, U. S. Geol. Survey Prof. Paper 203, 108-109, pl. 9, figs. 33-40; MILLER & COLLINSON, 1951, Jour. Paleontology, 25 (4), 479.
Aganides compressus MOORE, 1928, Mo. Bur. Geol.-Mines, ser. 2, 21, 283, pl. 13, figs. 7, 8; WILLIAMS, 1943, U.S. Geol. Survey Prof. Paper 203, 108, pl. 9, figs. 51-54.
Imitoceras compressum (Moore) MILLER & COLLINSON, 1951, Jour. Paleontology 25(4), 462, pl. 69, figs. 11, 12; VÖHRINGER, 1960, Geol. Rheinland-Westfalen Fortschritte, 3(1), 161; GORDON, 1965, U.S. Geol. Survey Prof. Paper 460, 171.
Imitoceras or *Gattendorfia louisianensis* (Rowley) HOUSE, 1962, Jour. Paleontology, 36(2), 263, 264.
Kazakhstania? louisianensis (Rowley) GORDON, 1965, Ibid. 171; MANGER, 1971, Jour. Paleontology, 45(1), 37, 38.

Evolute inner whorls of an ammonoid species with a simple 8-lobed suture are relatively common in shale partings within the lower Louisiana Limestone at and near the type locality in northeastern Missouri. The normal specimens are only about 3 or 4 mm in diameter, so none of this material can be regarded as having reached a growth stage allowing even a certain generic assignment. House (1962) has published a set of precise drawings based upon specimens from Buffalo Creek, a mile south of Louisiana; and he has observed that no close identity with *Protocanites* exists, as suggested earlier by Schmidt (1925) and others.

Various species of *Imitoceras* retain evolute whorls beyond the four volutions of growth observed in *I. louisianense,* while representatives of the related *Gattendorfia* typically retain this characteristic shell form until a diameter of about 10 mm and six volutions. The general configuration of the sutures, whorl section, and other criteria such as shell constrictions indicate that either *Imitoceras* or *Gattendorfia* is represented by this species. However, the genus *Imitoceras* is known to occur within the same stratum, whereas *Gattendorfia* has been found at a higher stratigraphic level. Therefore, these immature shells are being referred to the former genus; on the basis of a probability, they are also being regarded as conspecific with *Aganides compressus* Moore, 1928. That species is based upon a single fairly well preserved specimen from a locality about 20 miles down-river at Hamburg, Illinois. Moore's holotype is a mature shell nearly 40 mm in diameter; the whorls are slightly crushed, but suture and conch form are characteristic of other *Imitoceras* at about this stratigraphic level. In Vöhringer's scheme (1960), this species appears to fall within the "group of *I. spheroidale.*"

We are indebted to Dr. Jürgen Kullmann, Tübingen, who examined a collection of the small ammonoids from the Louisiana Limestone and advised us regarding their probable relationships. His conclusion was that the combination of characters portrayed at an immature stage indicates assignment to

uppermost Famennian (*Wocklumeria*-Stufe, to VI) or lower Tournaisian (*Gattendorfia*-Stufe, cuI).

Although traditionally a part of the Kinderhook Group, the Louisiana Limestone is now excluded from it. Authorities on conodont faunas and microfloras near the Devonian-Mississippian boundary have reached general agreement concerning the Devonian age of the Louisiana Limestone equivalents (*e.g.* Austin, et al., 1970), but a final boundary definition is still in abeyance. Conodonts of the *Siphonodella sulcata*-Zone, that constitute the base of the Carboniferous by definition, occur directly above the Louisiana. Ammonoids served to establish the original basis, but finer subdivision based upon microorganisms is now available.

The several Louisiana Limestone localities that have provided ammonoids are within the vicinity of the type locality in Pike County, Missouri and across the river at Hamburg, Calhoun County, Illinois. The only detailed information on their occurrence is at the Buffalo Creek locality (NW¼ Sec. 28, T. 54 N., R. 1 W.) where the small specimens have been secured from thin shale partings within the bottom two or three feet of a limestone bluff constituting the west side of Buffalo Hill.

All of the specimens of *Imitoceras louisianense* examined from Buffalo Creek are relatively well preserved limonitic internal molds; the sutures are clear and conch proportions are only slightly distorted. In contrast to published statements, the innermost portions and the protoconch can be observed. There are no real inconsistencies, for all of the available specimens appear to represent the same species. An adventitious lateral lobe appears in about the third suture (including the prosuture) and transverse constrictions were developed on the second or third volution of the conch. Rowley's specimens from Louisiana are stated to be preserved in pyrite and his drawings appear to be somewhat disproportionate in detail; otherwise they resemble the specimens now available for study.

Rowley's original types have not been reexamined and apparently have never been restudied. The late R. R. Rowley was a school teacher at Louisiana for many years who collected and described fossils from that vicinity; his extensive collection was sold to the University of Illinois after his death. Smith studied material from the Gurley Collection, now at the Field Museum in Chicago, although these specimens could have been secured directly from Rowley by purchase or trade.

Imitoceras intermedium Schindewolf, 1923
Pl. 1, figs. 11-15

?*Goniatites opimus* [part] WHITE & WHITFIELD, 1862, Boston Soc. Nat. Hist. Proc. 8, 305, figs.

?*Agoniatites opimus* [part] (White & Whitfield) WELLER, 1900, St. Louis Acad. Sci. Trans. 10, 121-123, pl. 8, fig. 1, pl. 9, fig. 1; SMITH, 1903, U.S. Geol. Survey Mon. 42, 32-33, pl. 7, figs. 1, 2.

Imitoceras intermedium SCHINDEWOLF, 1923, N. Jahrb, Min. etc. B.-Bd. 49, 333, pl. 16, figs. 2a,b; 1952, Senkenbergiana 32, 291, pl. 1, figs. 6,7; VÖHRINGER, 1960, Geol. Rheinland-Westfalen, Fortschritte 3(1), 131, pl. 3, figs. 2a,b,7,8.

Aganides intermedius (Schindewolf) SCHMIDT, 1925, Preuss. Geol. Landesanst. Jahrb. 45, 532, pl. 19, fig. 2.

Prionoceras intermedium (Schindewolf) PETTER, 1959, Algérie Publ. Serv. Carte géol., n.s., Paléont. Mém. 2, 251-252, pl. 19, figs. 8,8a,10,10a,12,12a.

?*Imitoceras opimum* (White & Whitfield) HOUSE, 1962, Jour. Paleontology, 36(2), 277-278.

The Iowa material referred to Schindewolf's species consists of several specimens fairly well preserved in fine-grained Prospect Hill Sandstone (Lower Mississippian), from a locality in southwestern Butler County, in the north central portion of the state. Also, tentatively identified with this

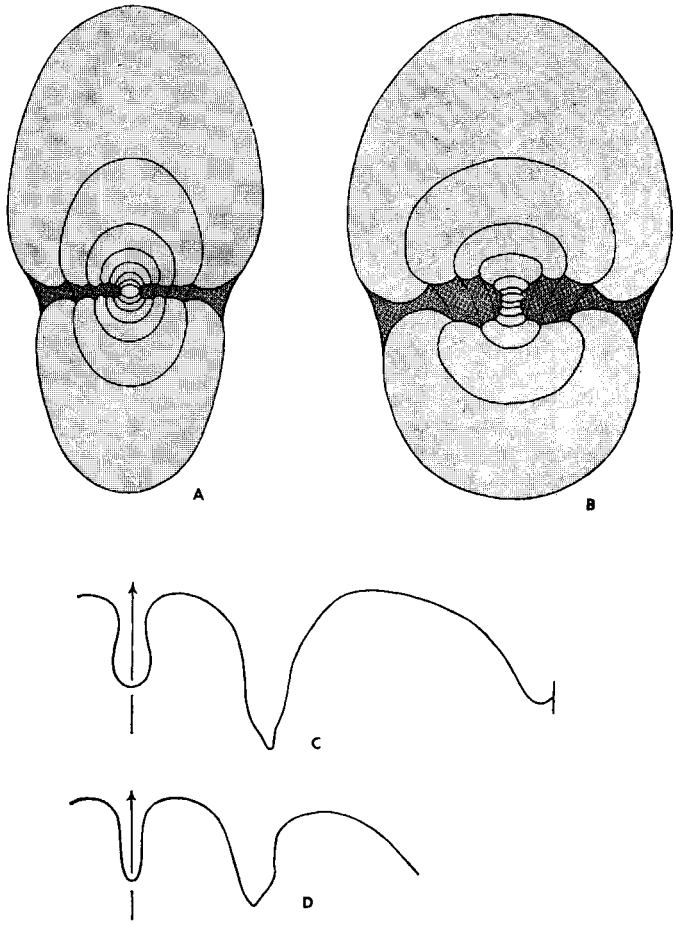

Figure 2. Transverse sections and sutures of Osagean (A, C) and Kinderhookian (B, D) *Imitoceras*. A, C, *I. ixion* (Hall). Cross section of a hypotype (SUI 13484), X5, and mature suture of a hypotype (SUI 13974) at a diameter of about 40 mm, X 3. Both from the type locality in the Rockford Limestone at Rockford, southern Indiana. B, D, *I. intermedium* Schindewolf. Cross section is modified from Vöhringer (1960) of a specimen, X6, from the Gattendorfia-beds at Hönnetal, Rhenish "Schiefergebirge." Suture is based upon a specimen (SUI 37059) from the Prospect Hill Sandstone in southwestern Butler County, north-central Iowa, at a diameter of about 20 mm, X5.

taxon are the lectotype and lectoparatype of *Goniatites opimus* White & Whitfield, from the English River Siltstone (Upper Devonian) at Burlington, in the southeast. The two types of that species that had been secured by White, were considered by House (1962) to be indeterminate; only preparation of these specimens or discovery of topotypes could alter this circumstance. Two clymeniids, found in association and originally included within the species *G. opimus*, were described by House as new species. Consequently, White & Whitfield's name is not distinguishable now, and the taxon should be relegated to the status of *nomen dubium*. A width/diameter ratio for *G. opimus* of 40 percent is not regarded as a valid character because of probable distortion; this same ratio in the types of *I. intermedium* and the better Butler County specimens approximates 60 percent.

The Devonian-Mississippian exposures in the Mississippi River bluffs of southeastern Iowa have been studied intensively, with considerable variance of opinion about their identity. A hundred years ago there were building-stone quarries in operation at Burlington. The upper portion of the English River Siltstone in this vicinity, known as the "*Chonopectus* Sandstone," is relatively well cemented in the uppermost foot and was used extensively in masonry construction. This portion of the section also contains the greatest concentrate of a molluscan-brachiopod fauna of interest to collectors at least since the time of Owen (1852). White made a detailed collection from this bed about 1860, and Weller (1900) has presented an account of the entire fauna. Stratigraphically, there is doubt about the equivalence or continuity of this fine-grained sandstone with the type English River of Washington County (Straka, 1968), although the contact with the overlying McCraney Limestone of Kinderhookian age is sharply defined. At Burlington, the large conch and fragmentary nature of *Cyrtoclymenia strigata* House in the *Chonopectus*-layer may have been neglected because of its apparent resemblance to a nondescript nautiloid; the holotype of that species lay unidentified in Iowa collections for 40 years until it was recognized as a clymeniid by House. Nevertheless, cephalopods are relatively rare in the sections along the Mississippi and quarrying operations in this part of the section are now greatly reduced. Sherman P. Lundy, a science teacher at Burlington who is studying the Maple Mill Formation as a research project, recently found a single small pyritized ammonoid in a shale exposure near the north edge of town. According to Brian F. Glenister (personal communication, 1972) this fossil was secured about 40 feet below the McCraney Limestone marking the base of the Kinderhook Series, and it represents *Falciclymenia* sp. That genus is restricted to the middle Upper Devonian, substantiating other criteria for correlation of the Maple Mill at Burlington.

In Butler County, north-central Iowa, ammonoids occur in a siltstone, below carbonates quite definitely identified as Maynes Creek Member of the Hampton Formation. The most authoritative information was secured by Anderson (his Locality 10, 1969) who established that this siltstone should be referred to as Prospect Hill, part of the Kinderhook Group, because of the occurrence of *Siphonodella quadruplicata*. Only a few miles to the northwest in Franklin County, there is a carbonate identified by Stainbrook (1950) as McCraney directly underneath the Prospect Hill, but this unit is not present at Anderson's Locality 10 just south of Austinville. The type locality for the Aplington Dolomite (a relatively thin Upper Devonian carbonate) lies only 5 miles east of the Prospect Hill ammonoid locality but the unit is not exposed on Beaver Creek and may not be represented there. A diverse molluscan fauna occurs in association with the ammonoids, and breviconic nautiloid cephalopods are relatively common; none adds to our knowledge concerning correlation or age assignment.

Type material from the English River at Burlington is apparently a part of the original C. A. White Collection, purchased by the University of Michigan. These specimens were secured about 1860, prior to White's tenure as Iowa State Geologist, and the duplicate specimen (lectoparatype) was deposited in the American Museum by Whitfield. The associated clymeniids are scattered in collections at Harvard (Mus. Comp. Zool.), Field Museum (Walker Mus. Coll.), American Museum (Natural Hist.), University of Michigan (Mus. Paleont.), and University of Iowa. Some of these ammonoids had been found by Samuel Calvin and by Stuart Weller many years later than those by White. Six specimens from Butler County in north-central Iowa, were collected by M. A. Stainbrook in 1946; they are catalogued in the University of Iowa Collections (SUI 11511, 37058, and 37059). Stainbrook correctly interpreted the stratum as Prospect Hill. Also, Michael R. House studied this collection of ammonoids in 1960 and concluded that they were more likely of Carboniferous age than Devonian (personal communication).

Imitoceras jessieae (Miller & Gurley, 1896)
Pl. 1, figs. 5-7

Goniatites jessieae MILLER & GURLEY, 1896, Ill. St. Mus. Nat. Hist. Bull. 11, 46, pl. 5, figs. 18-20.

Aganides jessieae (Miller & Gurley) SMITH, 1903, U. S. Geol. Survey Mon. 42, 115, pl. 17, figs. 18-20.

Imitoceras jessieae (Miller & Gurley), MILLER & COLLINSON, 1951, Jour. Paleontology, 25 (4), 465-466, pl. 69, figs. 13-15.

Imitoceras abundans MILLER & COLLINSON, 1951, Ibid., 460-462, pl. 68, figs. 1-8, pl. 69, figs. 7,8.

Imitoceras discoidale (Smith) MILLER & COLLINSON, 1951, Ibid., 463-465, pl. 68, figs. 9-11.

There is currently no real basis for evaluation of the various specific names applied to representatives of *Imitoceras* from the Lower Mississippian of North America. Also, judging by other ammonoid taxa, it must be assumed that some of the 40 to 50 species named occur in both America and Eurasia-Africa; *I. rotatorium* (deKoninck), the type species from Belgium Lower Carboniferous, and Münster's species from German Upper Devonian, carry about a century of priority over some other names. Critical details are generally lacking. Vöhringer (1960) arranged the European species systematically, primarily on the differences in ontogeny and shell form. Gordon (1965) made an effort to present a key for American species, but without considering possible European counterparts or growth modifications. *Goniatites ixion* Hall, 1879, from Rockford, Indiana, has normally been regarded as a synonym of deKoninck's species *rotatorius*. However, hundreds of large (50 to 100 mm) specimens have been secured from Rockford, and they show reasonably consistent differences from deKoninck's type, particularly in the much deeper lateral lobe of the suture. A remarkably clear photograph of the holotype of *I. rotatorium* was published by Delépine (1940).

The lectotype of *I. jessieae* is a well preserved mature shell about 40 mm in diameter; a paralectotype is about 50 percent larger (Miller & Collinson, 1951). The width/diameter proportion for this species is about 45-50 percent, with possibly a slight compression; many of the ammonoids from the Chouteau Limestone in Missouri are obviously distorted. Apparently, there is a close resemblance in shell form to *I. rotatorium,* the type species, although that species is larger. As a general rule, the ontogenetic stages of American Mississippian species have not been sufficiently investigated to provide a basis for comparing specimens of different sizes. The Rockford *I. ixion* is globular and somewhat involute by the second whorl and a diameter of only 2 mm (Miller & Furnish, 1957); by the seventh volution and 25 mm diameter the width/diameter ratio is about 50 percent, but this proportion is reduced to 35 percent at 100 mm diameter.

The original collections of *I. jessieae,* and most of the more recently acquired representatives of the species, have been secured from the Chouteau Limestone of central Missouri. In that area, for example from Pettis to Calloway County, the formation reaches a thickness of 60 to 70 feet (Branson, 1938) and lies unconformably below the Burlington Limestone of the Osagean Series. Farther to the northeast in Missouri, the Chouteau Limestone is regarded by Branson (1938) and Canis (1968) as being sporadic in occurrence. An apparent outlier of Chouteau in Knox County, where two *Imitoceras* have been found, is just 20 miles from the Iowa state line and, in part, has a lithologic resemblance to the Wassonville Formation of Iowa, a presumed equivalent. In Washington County, Iowa, type Wassonville Dolomite contains representatives of small *Imitoceras* preserved in white chert, that were referred to *I. abundans* and *I. discoidale* by Miller & Collinson (1951). The three species are recorded as occurring together in the Chouteau and normally cannot be distinguished with certainty. For practical purposes, both are being treated as synonyms of *I. jessieae.*

Genus *Pericyclus* Mojsisovic, 1882

Type species: *Goniatites princeps* deKoninck, 1842; S.D., Hyatt, 1884, p. 330.

A portion of the Mississippian (Dinantian-Lower Carboniferous) of Europe has been designated the *Pericyclus*-Stufe and the genus is abundantly represented there. The suture and whorl-form in the genus is similar to *Muensteroceras,* relatively common in America, but the conch of *Pericyclus* is strongly ribbed. A complex group of taxa at the subgeneric level has been recognized, and most authorities now consider *Ammonellipsites* to be the senior designation generically.

Goniatites blairi Miller & Gurley, 1896, has been referred to *Pericyclus* by various authors, including Smith (1903). Miller & Collinson (1951) refigured the holotype of this species and also identified other Chouteau specimens as the same form. In none of these shells has a suture been observed; so it is probable that almost all represent gastropods, rather than ammonoids. The few that we have examined are distinctly not cephalopods.

Elsewhere in North America, pericyclids have been found in Alaska, Western Canada, Kentucky, and possibly New Mexico and Nevada. The family is normally associated with a shale facies, rather than with the shelf carbonates of the Central Interior.

Genus *Prodromites* Smith & Weller, 1901

Type species: *Goniatites gorbyi* Miller, 1891; O.D.

A curious ceratitic genus first discovered by W. F. E. Gurley and described by S. A. Miller from the Chouteau Limestone of central Missouri is still an enigma phylogenetically. These ammonoids have been eagerly sought, for most of the specimens are spectacular, but the genus is still known from relatively few specimens in only six general localities within central United States. Miller & Collinson (1951) have given the most detailed account of these forms and concluded that all known specimens fall in the single species.

Critical ontogenetic stages in *Prodromites* have not yet been studied, and most of the material available does not lend itself to examination of the inner whorls. It can be observed that the first four whorls are evolute; there are faint ribs on some specimens but no constrictions. In this inner portion of the conch, also, the predominant element in the suture is a large undivided ventral lobe (Text-fig. 3). These characters, and other features as well, suggest a prolecanitid relationship. Multiple auxilliary lobes in the suture of other taxa can be observed to be somewhat of a response mechanically to a thinly-lenticular involute shell form. Logically, then, no particularly close relationship need be expected with other multilobate genera of the Late Paleozoic. As Smith observed

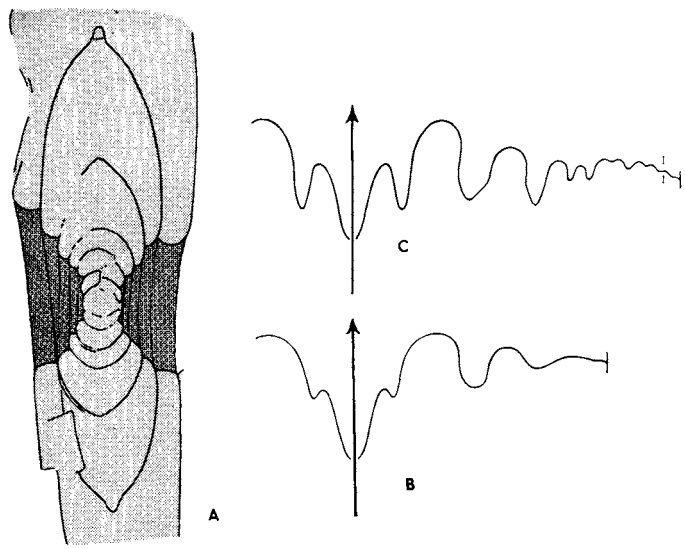

Figure 3. Transverse section and sutures of inner volutions in *Prodromites gorbyi* (Miller) from Missouri. A, is a hypotype (SUI 13929), X20, from Chouteau Limestone about 3½ mi. north of Sedalia, Pettis County—the inner portions of a specimen about 17 mm in diameter illustrate that the first four volutions are highly evolute with relatively broad whorls and are not indicative of the narrow involute conch form assumed by the later whorls. B, C, represent sutures of a well preserved hypotype (SUI 9549) from the Northview, Webster County (Pl. 1, fig. 10) at a diameter of about 6 mm, X30, and a diameter of about 13 mm, X17. The second suture prior to fig. B is similar but appears to have a deep undivided ventral lobe. Innermost volutions on this specimen are not preserved.

70 years ago, a gap in the record and obvious differences in morphology seem to preclude a direct connection with the Devonian (Frasnian) beloceratids or triainoceratids (Bogoslovsky, 1969) although the similarity is striking. Still, no direct ancestry is known. Schindewolf (1959) described a goniatite from basal Mississippian strata of Alberta that he considered was related to *Prodromites*. As he indicated, there is a similarity; but the three immature specimens are distinct from any known genus of ammonoid.

At Burlington, Weller apparently secured a single well preserved *Prodromites* from the Wassonville Dolomite, just above the Starrs Cave Oolite contact. On various bases, this stratigraphic horizon is believed to correspond directly to the lower Chouteau Limestone of central Missouri, where most of the *Prodromites* specimens have been found. The northern Indiana occurrence recorded by Gutschick & Treckman (1957) is also believed to fall at the same level (Rexroad & Scott, 1964). The goniatite-bed at Rockford, central Indiana, and the Northview Siltstone and Shale beds with goniatites in southwestern Missouri, with *Prodromites*, are thought to lie appreciably higher in the section than the Chouteau ammonoid occurrences.

Genus *Protocanites* Schmidt (*in* Paeckelmann), 1922

Type species: *Goniatites lyoni* Meek & Worthen, 1860; O.D.

One of the most widespread of the Lower Mississippian ammonoid genera is an evolute simple prolecanitid. These forms are extremely rare in the Chouteau Limestone, where only a single specimen was found by E. B. Branson in central Missouri. Two representatives are known from the Northview, to the southwest.

The progenitor of an important lineage, the Prolecanitaceae, is represented in collections from Indiana, but is not common there. Isolated representatives of *P. lyoni*, or closely related species, have been found widely in the United States and Canada. The genus is well represented in Eurasian beds of Tournaisian age. Elsewhere, similar forms have been found in Africa, Australia, and South America. Normally, this lineage seems to be more common in association with dark-colored argillaceous sediments.

REFERENCES

ANDERSON, W. I. 1964. Upper Devonian and Lower Mississippian Conodont Faunas, North-central Iowa. *Proc. Iowa Acad. Sci.*, 71:320-334.

_____. 1966. Upper Devonian Conodonts and the Devonian-Mississippian Boundary of North-central Iowa. *Jour. Paleontology* 40(2):395-415, pl. 48-52.

_____. 1969. Lower Mississippian Conodonts from Northern Iowa. Ibid. 43(4):916-928, pl. 107-109.

AUSTIN, R., *et al.* 1971. Les Couches de Passage du Dévonien au Carbonifère de Hook Head (Irlande) au Bohlen (D.D.R.). *Carb. Strat. Colloque, Cong.-Coll. Univ. Liège* 55:167-177.

BENDER, PETER, *et al.* 1971. Die stratigraphische Gliederung des Dinantiums und seiner Ablagerungen in Deutschland (by Arbeitsgemeinschaft für Dinant-Stratigraphie). *Newsletter Stratigr.* 1(4):7-18.

BOGOSLOVSKY, B. I. 1969. Devonskie Ammonoidey; I. Agoniatity. *Akad. Nauk SSSR, Paleont. Inst. Trudy* 124:341 pp., 29 pl.

BRANSON, E. B., *et al.* 1938. Stratigraphy and Paleontology of the Lower Mississippian of Missouri. Mo. Univ. Studies 13(3,4): 205 and 242 pp., 48 pl.

CAMPBELL, K. S. W. and B. A. ENGEL. 1963. The Faunas of the Tournaisian Tulcumba Sandstone and Its Members in the Werrie and Belvue Synclines, New South Wales. *Geol. Soc. Australia* 10(1):55-122, 9 pl.

CANIS, W. F. 1968. Conodonts and Biostratigraphy of the Lower Mississippian of Missouri. *Jour. Paleontology* 42(2):525-555, pl. 72-74.

COLLINSON, CHARLES. 1961. The Kinderhookian Series in the Mississippi Valley. Kansas Geol. Soc. 26th Ann. Field Conf. GdBk. 100-109.

_____, *et al.* 1967. *Devonian of the North-central Region, United States.* Internat. Symposium Dev. System, Calgary. 1:933-971.

_____, C. B. REXROAD, and T. L. THOMPSON. 1971. Conodont Zonation of the North American Mississippian. *Geol. Soc. America Mem.* 127:353-395.

DELEPINE, G. 1940. Les Goniatites du Dinantien de la Belgique. *Belg. Mus. Royal Hist. Nat. Mém.* 91:91 pp., 5 pl.

DORHEIM, F. H., D. L. KOCH, and M. C. PARKER. 1969. *The Yellow Spring Group of the Upper Devonian in Iowa.* Iowa Geol. Survey Rept. Invest. 9:30 pp.

GORDON, M. JR. 1965. Carboniferous Cephalopods of Arkansas. U.S. Geol. Survey Prof. Paper 460, 322 pp., 30 pl.

GUTSCHICK, R. C., and J. F. TRECKMAN. 1957. Lower Mississippian Cephalopods from the Rockford Limestone of Northern Indiana. *Jour. Paleontology* 31(6):1148-1153, pl. 143, 144.

HOUSE, M. R. 1962. Observations on the Ammonoid Succession of the North American Devonian. *Jour. Paleontology* 36(2):247-284, pl. 43-48.

KULLMANN, JURGEN. 1960. Die Ammonoides des Devon im Kantabrischen Gebirge (Nordspanien). *Akad. Wiss. Lit. Abh. Math-naturwiss. Klasse* 7:457-559, 9 pl.

_____. 1961. Die Goniatiten des Unterkarbons im Kantabrischen Gebirge (Nordspanien), I. Stratigraphie. Paleontologie der U. O. Goniatitina Hyatt. *N. Jahrb. Geol. Paläont., Abh.* 113(3):219-326, pl. 19-23.

LAUDON, L. R. 1931. The Stratigraphy of the Kinderhook Series of Iowa. *Iowa Geol. Survey* 35:333-451.

LIBROVITCH, L. S. 1940. Carboniferous Ammonoids of North Kazakhstan. In, *Paleontology of USSR.* 4(9):394 pp., 25 pls. (Akad. Nauk SSSR, Paleont. Inst.).

_____. 1962. Nadotryad Ammonoidea (Lower and Middle Carboniferous). In V. E. Ruzhencev, Ed., Osnovy paleontologii, Pt. 5, Molliuski, Akad. Nauk SSSR, 243-424, 32 pl.

LINEBACK, J. A. 1963. Age of the Rockford Cephalopod Fauna (Mississippian) of Southern Indiana. *Jour. Paleontology* 37(4): 939-942.

MANGER, W. L. 1971. The Mississippian Ammonoids *Karagandoceras* and *Kazakhstania* from Ohio. *Jour. Paleontology* 45(1): 33-39, pl. 12.

_____. 1971. The Position and Age of the Sciotoville Bar Locality, Southern Ohio. *Ohio Jour. Sci.* 71(5):284-291.

MATHEWS, S. C. 1971. Comments on Paleontological Standards for the Dinantian. 6e Carb. Cong. Intern. Strat. Géol. (Sheffield, 1967), C. R. 3:1159-1164.

MEHL, M. G. 1960. The Relationships of the Base of the Mississippian System in Missouri. Denison Univ. Sci. Lab. Jour. 45(5):57-107.

MILLER, A. K., and CHARLES COLLINSON. 1951. Lower Mississippian Ammonoids of Missouri. *Jour. Paleontology* 25(4):454-487, pl. 68-71.

_____, and W. M. FURNISH. 1957. Permian Ammonoids from Southern Arabia. Ibid. 31(6):1043-1051, pl. 131, 132.

——— and ———. 1958. Goniatites of the Burlington Limestone in Missouri. Ibid. 32(2):269-274, pl. 35.

_____, and H. F. GARNER. 1955. Lower Mississippian Cephalopods of Michigan; Part 3, Ammonoids and Summary. Univ. Mich. Contr. Mus. Paleontology 12(8):113-173, 7 pl.

_____, and WALTER YOUNGQUIST. 1947. The Discovery and Significance of a Cephalopod Fauna in the Mississippian Caballero Formation of New Mexico. *Jour. Paleontology* 21(2):113-117, pl. 27, 28.

MOORE, R. C. 1928. *Early Mississippian Formations of Missouri.* Missouri Geol. Survey 21: 2nd. Ser., 283 pp.

MULLER, K. J. 1962. A Conodont Fauna from the Banff Formation, Western Canada. *Jour. Paleontology* 36(6):1387-1391.

PAREYN, CLAUDE. 1961. Les Massifs Carbonifères du Sahara Sud-Oranais. Centre Recherches Sahariennes Publ., Géol. Sér. 1(2): 244 pp., 28 pl.

PARKER, M. C., *et al.* 1968. *Mississippian (Osage and Kinderhook) Stratigraphy and Mississippian-Devonian Boundary Problems in Southeast Iowa.* Geol. Soc. America, North-central Sec., Gdbk. Fld. Trip 3, 28 pp.

PETTER, G. 1959. Goniatites dévoniennes du Sahara. Publ. Serv. Carte Géol. Algérie, Mém. (n.s.) Paléont. 2, 371 pp., 26 pl.

REXROAD, C. B., and A. J. SCOTT. 1964. Conodont Zones in the Rockford Limestone and the Lower Part of the New Providence Shale (Mississippian) in Indiana. Ind. Geol. Survey Bull. 30: 54 pp., 3 pl.

SCHINDEWOLF, O. H. 1923. Beitrage zur Kenntnis des Paläozoicums in Oberfranken, Ostthüringen und dem Säcksischen Vogtlande; 1. Stratigraphie und Ammoneenfauna des Oberdevons von Hof a.S. *N. Jahrb. Min.*, etc., B. -Bd. 49:250-357, 393-509, pls. 14-18.

_____. 1959. Adolescent Cephalopods from the Exshaw Formation of Alberta. *Jour. Paleontology* 33(6):971-976, pl. 120, 121.

SCHMIDT, H. 1925. Die Carbonischen Goniatiten Deutschlands. Preuss. Geol. Landesenstalt Jahrb. 1924, 609 pp., pl. 19-26.

SCOTT, A. J., and CHARLES COLLINSON. 1961. *Conodont Faunas from the Louisiana and McCraney Formations of Illinois, Iowa, and Missouri.* Kansas Geol. Soc. 26th Ann. Field Conf. Gdbk., 110-141, 2 pl.

SMITH, J. P. 1903. Carboniferous Ammonoids of America. U.S. Geol. Survey, Mon. 42:211 pp., 29 pl.

STAINBROOK, M. A. 1950. The Fauna and Correlation of the McCraney Limestone of Iowa and Illinois. *Amer. Jour. Sci.* 248:194-213.

STRAKA, J. J. II. 1968. Conodont Zonation of the Kinderhookian Series, Washington County, Iowa. Iowa Univ. Studies Nat. Hist. 21(2), 71 pp., 7 pl.

THOMPSON, T. L., and L. D. FELLOWS. 1970. *Stratigraphy and Conodont Biostratigraphy of Kinderhookian and Osagean Rocks of Southwestern Missouri and Adjacent Areas.* Missouri Geol. Survey and Water Resources, Rept. Invest. No. 45, 34 figs., 10 pl.

VOGES, A. 1960. Die Bedeutung der Conodonten für die Stratigraphie des Unterkarbons I und II (Gattendorfiaund Pericyclus-Stufe) im Sauerland. *Fortschr. Geol. Rheinld.-Westf.* 3(1):197-228, 5 pl.

VOHRINGER, E. 1960. Die Goniatiten der Unterkarbonischen Gattendorfia-Stufe im Hönnetal (Sauerland). *Fortschr. Geol. Rheinld. Westf.* 3(1):107-196, 7 pl.

WEDEKIND, R. 1918. Die Genera der Palaeoammonoidea (Goniatiten). *Palaeontographica* 62:85-184, pl. 14-22.

WELLER, STUART. 1900. Kinderhook Faunal Studies. II. The Fauna of the Chonopectus Sandstone at Burlington, Iowa. *St. Louis Acad. Sci. Trans.* 10(3):57-129, 9 pl.

WEYER, DIETER. 1965. Zur Ammonoideen-Fauna der Gattendorfia-Stufe von Dzikowiec (Ebersdorf) in Dolny Slask (Niederschlesien), Polen. *D.D.R. Geol. Gesellschaft Ber.* 10(4):443-464, pl. 6-8.

WILLIAMS, J. S. 1943. *Stratigraphy and Fauna of the Louisiana Limestone of Missouri.* U.S. Geol. Survey Prof. Paper 203, 133 pp., 9 pl.

WORKMAN, L. E., and TRACEY GILLETTE. 1956. *Subsurface Stratigraphy of the Kinderhook Series in Illinois.* Ill. Geol. Survey Rept. Inv. 189, 46 pp.

ZIEGLER, W. 1969. Eine neue Conodontenfauna aus dem höchsten Oberdevon. *Geol. Rheinl.-Westf.* 17:343-360, pl. 1, 2.