Art. XXVII.—*The Age of the Eurypterids of Kokomo, Indiana;** by E. M. Kindle.

The small but interesting Eurypterid fauna which characterizes the Kokomo limestone of Indiana has recently been admirably described and figured by Doctor J. M. Clarke and Doctor Ruedemann† in connection with the Eurypterid faunas of New York. The opinion concerning the age of this remarkable fauna which these authors express, however, invites discussion since it is at variance with the view of some geologists who have a knowledge of the field relations of the beds holding it and of the formation with which it is correlated. The matter seems to be of sufficient importance to justify a brief review of the evidence bearing on the question of the age of the beds. If, as Clarke and Ruedemann state, the Kokomo Eurypterid fauna is of Lockport age, it may well stand in an ancestral relation to the New York Salina Eurypterid faunas which they describe. This is the conclusion which the reader is apt to draw from an inspection of the tables on pages 91, 93, and 431‡ and the discussion of the new subgenus *Onychopterus* from Kokomo. The other elements of the Kokomo fauna and the stratigraphy of the region do not, in the writer's opinion, bear out this inference.

Clarke and Ruedemann correlate the Kokomo limestone with the Noblesville limestone of Indiana and the Lockport of New York, and use indiscriminately the terms Kokomo limestone, Kokomo waterlime and Noblesville waterlime.§

This correlation is in harmony with a suggestion made by Schuchert, who, in a review of the writer's work on the "Stratigraphy and Palæontology of the Niagara of Northern Indiana," suggested the probable absence "of the water-lime horizon in Northern Indiana."‖ Schuchert was probably in part influenced in expressing this opinion by the still earlier reference of *Conchidium colletti*, the most conspicuous brachiopod of the Kokomo fauna, to the Niagara limestone by Hall and Clarke.¶ The writer had, at the time Schuchert's review appeared, a nearly complete collection of the Kokomo fauna and intended, when opportunity for its illustration offered, to present the strong array of evidence which it furnished against the inferred equivalence of the Kokomo and Lockport faunas. Other duties intervened however, and at a comparatively recent

* Published with the permission of the Director of the Geological Survey of Canada.

† Memoir New York State Museum, No. 14, vols. i and ii, 1912.

‡ Ibid. § Ibid, pp. 320, 351, 215.

‖ This Journal, Dec. 1904, p. 467.

¶ Pal. N. Y., vol. viii, pt. II, pl. 66, 1894.

date most of the Kokomo fauna was described by Dr. Aug. Foerste. Now that both the Kokomo and Niagaran faunas of northern Indiana have been described, it is in order to examine the evidence which they afford regarding the question of their equivalence as advocated by Clarke and Ruedemann, or their succession as believed by the writer.

The Kokomo fauna occurs in a limestone which in the earlier references to it was generally called the "water-lime" beds or Water-lime Group.* The name Kokomo limestone was introduced for these beds by Foerste† in 1904. They are exposed in various quarries in the vicinity of Kokomo, where they lie horizontal and are covered by drift except where uncovered by quarry operations. The character of the beds of this limestone and the stratigraphic relations of the eurypterid and non-eurypterid faunas which characterize different parts of them can best be understood by reference to a section of one of the quarries in the Kokomo limestone. The section exposed at the Geo. Defenbaugh quarry on the south side of Kokomo (N. W. $\frac{1}{4}$ sec. 6 T. 23 N. R. 4E.) is as follows:

Section of Kokomo limestone.

1.	Drab to grey non-magnesian limestone, with chert bands and containing a brachiopod fauna	4′
2.	Thin-bedded and finely-laminated dark-grey limestone, with eurypterids, and lying in strata 1″–2″ thick which on weathering split still thinner. This bed contains occasional pockets of asphaltum and crude oil	6′
3.	Grey limestone ("cement rock")	4′
4.	Dark-bluish grey argillaceous limestone	2′
5.	Dark grey limestone in even bedded ledges 6″ to 8″ thick	6′
6.	Very hard thin-bedded strata of brownish grey to bluish limestone	6′
7.	Blue and light grey banded limestone, the layers very thin, smooth, and even bedded and giving a variegated appearance to the stone	4′
		32′

Eight or ten feet more of beds similar to those of the section given above are penetrated by some of the quarries but these were not seen by the writer. As in the water-limes of New York the eurypterid and non-eurypterid faunas appear to be confined to distinct parts of the section. The writer was able to discover no trace of the brachiopod fauna which characterizes bed number one below it, nor have any eurypterids ever

* E. W. Claypole, Am. Geol. vol. vi, p. 261, 1890. A. J. Phinney, 11th Ann. Rept. U. S. Geol. Surv., pt. I, pp. 632-3, 1891. S. A. Miller, 17th Rept. Ind. Dept. Geol. & Nat. Res., p. 33, 1892.

† 28th Ann. Rept. Ind. Dept. Geol. & Nat. Res. p. 33, 1904.

been found in this bed so far as known. The eurypterids occur in bed number two and probably in various other beds below it. Most of the beds and probably all of them below number one contain a notable amount of magnesia.

The most prominent general characteristic of the lithology of these beds is the very even bedding and generally thin lamination. This strikingly developed feature distinguishes the Kokomo limestone sharply from any of the known types of the Noblesville dolomite. The latter *never* shows thin lamination or marked evenness of bedding. Frequently the bedding planes of the Noblesville are so obscure as to make their recognition difficult. When they are well marked the distinct, clear cut, horizontal, and even lamination of the Kokomo beds is never present. Sometimes, as in the case of outcrops on the Wabash river below Peru, the irregularity of bedding takes the form of cross bedding. The well marked physical peculiarities which distinguish the Kokomo limestone from the Noblesville dolomite are so pronounced that there is no good reason for confusing the two by using such a term as "Noblesville waterlime."*

A geologist familiar with the sharp contrasts shown by the lithology of the Kokomo and the Noblesville formations would indeed be surprised if he found the same fauna in each. But the faunas and the lithology are quite harmonious in indicating that the Kokomo and Noblesville represent entirely distinct formations. The evidence of the fossils can best be shown by presenting a list of the species collected by the writer at the type locality of the Noblesville dolomite for comparison with the fauna of the Kokomo limestone.

Noblesville dolomite fossils from Connors Mill, Hamilton County, Indiana.

Strophonella cf. *striata* Hall.
Strophonella williamsi Kindle.
Leptaena rhomboidalis Wilckens.
Plectambonites cf. *sericeus* Sowerby.
Dalmanella elegantula Dalman.
Rhipidomella hybrida Sowerby.
Conchidium cf. *multicostatum* Hall.
Atrypa calvini Nettleroth.
Atrypa reticularis Linnæus.
Spirifer nobilis Barrande.
Spirifer radiatus Sowerby.
Spirifer (*Reticularia*) *crispa* var. *simplex* Hall.
Meristina maria Hall.
Platyceras (*Diaphrostoma*) *cornutum* Hisinger.

* Mem. N. Y. State Museum, No. 14, p. 215, 1912.

Illaenus insignis Hall.
Encrinurus indianensis Kindle.
Calymene vogdesi Foerste.
Ceraurus (*Crotalocephalus*) *niagarensis* Hall.
Sphaerexochus romingeri Hall.
Phacops cf. *pulchellus* Foerste.

The list of fossils of the Kokomo limestone which follows is believed to include all of the fossils which have been described from this formation. It is based upon the work of Claypole,* Miller†, White‡, Foerste§, and Clarke and Ruedemann.‖

Fossils of the Kokomo limestone, Kokomo, Indiana.

Buthotrephis divaricata David White.
Buthotrephis newlini David White.
Amplexus septatus Foerste.
Favosites pyriform-kokomoensis Foerste.
Chonetes colliculus Foerste.
Leptaena rhomboidalis Wilckens.
Spirifer exiguus Foerste.
Spirifer corallinensis Grabau.
Whitfieldella erecta Foerste.
Anoplotheca congregata Kindle.
Dalmanella elegantula Dalman.
Pentamerus divergens Foerste.
Conchidium colletti Miller.
Wilsonia kokomoensis Miller.
Isochilina musculosa Foerste.
Kloedenia kokomoensis Foerste.
Eurypterus ranilarva Clarke & Ruedemann.
Eurypterus (*Onychopterus*) *kokomoensis* Miller & Gurley.
Eusarcus newlini (Claypole).
Stylonurus (*Drepanopterus*) *longicaudatus* Clarke & Ruedemann.

Comparison of the two lists shows that two wholly different faunal types are represented. If we compare the fauna of the Noblesville limestone with that of the whole recorded Niagaran fauna of northern Indiana, that is the combined faunas of the Noblesville and the Huntington, we get a nearly complete discordance. Only a single species, if we except the long ranging *Leptaena rhomboidalis*, is common to

* Am. Geol. vol. vi, pp. 258–260, 1890.
† 17th Rept. State Geol. of Ind. 1891, p. 77, pl. 13, figs. 5-6, 1892. III. State Mus. Bull. 10, 1896, p. 90, pl. 5, fig. 1. 18th Rept. State Geol. of Ind., 1893. p. 312, pl. 9, figs. 22–24, 1894.
‡ Proc. U. S. Nat. Mus., vol. xxiv, pp. 269–270, pl. xvi-xviii, 1901.
§ Jour. Cin. Soc. Nat. Hist., vol. xxi, pp. 1–39, pl. i, 1909.
‖ Mem. N. Y. State Mus., No. 14, vol. i-ii, pp. 1–628, pls. 1–88, 1912.

the two. It may be observed that one species which Foerste finds in the Kokomo fauna, *Anoplotheca congregata*, was described by the writer in connection with the faunas of the Noblesville and Huntington dolomites, but in connection with the description the statement was made that "the species apparently does not belong to the Niagaran fauna and is probably a representative of the "Waterlime" fauna.* The occurrence in the Kokomo fauna of a *Wilsonia* and of *Dalmanella elegantula* might be cited as suggestive of a Lockport horizon. The *Wilsonia*, however, is a distinct species from that found in the Noblesville and Huntington and the *Dalmanella elegantula* is described as "a small variety" of that species by Foerste. The lack of harmony of the remainder of the fauna with that of the Lockport appears however to indicate that these species represent a heritage from the Lockport. They belong, as Hyatt remarks of certain groups of fossils, to "types which remain comparatively simple, or do not progress to the same degree as others of their own group."† In association with other fossils of distinctly post-Lockport type *Dalmanella elegantula* clearly fills the rôle of a late survivor of an early fauna just as *Phacops rana* does in the Portage or *Rhipidomella vanuxemi* in the Chemung. It is a survivor of a fauna which has been almost completely replaced by later types. The presence in the Kokomo fauna of a *Conchidium* cannot be taken as evidence of its Lockport age. In the Indiana province *Conchidium* persists through the Huntington dolomite, which is the representative of the Guelph in that region. It is true that *C colletti* is not allied to the Huntington species, but neither is it to any of the Noblesville species of the genus. Its specific characteristics are markedly different from those of any Noblesville *Conchidium*. If comparison of this shell is made with *C. laqueatum*, the form nearest to it in the Noblesville, it will be seen to have about double the number of plications characteristic of that species. The remarkable expansion and flattening of the front of the shell sharply differentiates it not only from this but from all other species of *Conchidium*. It recalls the extravagant expansion in sub-parallel planes of the anterior portion of the shell of *Atrypa reticularis* which is shown by certain varieties in the later stages of its phylogenetic history. A primitive pentameroid feature which some of the Lockport species of *Conchidium* exhibit very distinctly in a non-plicated umbonal area is conspicuously absent in *C. colletti*. The fine plications and their complete extension over the umbones in *C. colletti* suggest that it belongs to the latest surviving type of the genus.

* 28th Ann. Rept. Ind. Dept. Geol. & Nat. Res., p. 445, 1904.

† Phylogeny of an Acquired Characteristic. Proc. Am. Phil. Soc., vol. xxxii, 1895.

Whatever inferences regarding the age of the Kokomo fauna might have been drawn from the two or three species originally ascribed to it in the Indiana Reports, the fauna at present known affords no satisfactory ground for correlating it with the Noblesville dolomite of Indiana or the Lockport of New York. So unlike are the characteristic features of each that no geologist with a knowledge of the Noblesville and Kokomo faunas derived from a field study of the beds holding them would ever be likely to think of the possibility of the identity of the two. Trilobites constitute one of the important and almost invariably present elements of the Noblesville faunules which is entirely absent from the Kokomo fauna. Scarcely a faunule has been collected from the Noblesville by the writer which did not include *Sphaerexochus romingeri* or some other species of *Illaenus*. The entire absence from the Kokomo limestone of gasteropods, which are common both in the Noblesville and Huntington formations, serves also to emphasize the difference between the two.

Since a comparison of the faunas does not appear to justify the correlation of the Kokomo with the Noblesville we may next inquire briefly what correlation the fauna does suggest. The only plants which are known from the Kokomo limestone were described by David White from specimens transmitted by the writer. Concerning the relationship of the two new species of *Buthotrephis* which Mr. White recognized in these, he states, "Of all the species as yet ascribed to this genus that which seems to be most closely related to the fossils in hand is *Buthotrephis lesquereuxii* described by Grote and Pitt from the Waterlime (Cobleskill) near Buffalo, N. Y."* White correlated the beds which furnished these plants with the "Round-out of Schuchert and Clarke.† (Cobleskill of the present N. Y. State Survey nomenclature.)

The species which Foerste has reported from the Kokomo limestone include one characteristic species of the Cobleskill dolomite of New York, *Spirifer corallinensis* Grabau, together with several which have their nearest allies in Salina or Cobleskill species. One of the ostracods Foerste finds closely related to *Isochilina grandis latimarginata*, a species which in Manitoba occurs above the gypsum beds which are believed to be of Salina age. The other ostracod in the Kokomo fauna Foerste finds closely related to a Decker Ferry species. Foerste's study of the fauna leads him to conclude that the Eurypterid horizon and probably the brachiopod horizon are of Salina age.‡

The absolute unlikeness of the Kokomo fauna and the faunas of the closely adjacent exposures of the Noblesville and Hunt-

* Proc. U. S. Natl. Mus., vol. xxiv, p. 267, 1905. † Ibid., p. 265.
‡ Jour. Cin. Soc. Nat. Hist., vol. xxi, p. 6, 1909.

ington formations appears to afford no grounds for their correlation. The presence in the Kokomo fauna, on the other hand, of species which are represented by identical or nearly allied species in the Salina or Cobleskill indicates that it represents either a Salina or Cobleskill horizon.

The eurypterids appear to afford no direct evidence concerning the age of the beds since none of the Kokomo species have been recognized outside the Kokomo district by Clarke and Ruedemann. One of the Kokomo species however is closely enough allied to *Eurypterus lacustris* of the Bertie waterlime to have lead Professor Claypole* to cite this species from the Kokomo limestone. Clarke and Ruedemann recognized in *Drepanopterus* characters which they suppose to be ancestral to those of certain New York Salina eurypterids. Phylogenetic evidence will undoubtedly become of increasing value in correlation as our knowledge of the history of biologic groups increases in completeness. But in the present state of our knowledge of the very imperfectly known Eurypterida this kind of evidence cannot be given much weight when, as already pointed out, it is opposed by direct evidence. The absence from the Kokomo eurypterid fauna, according to Clarke and Ruedemann, of any species common to it and any of the well known eurypterid horizons above the Lockport in the Silurian of New York, suggests a lack of identity between the Kokomo and any one of these horizons. It however affords no evidence that the Kokomo fauna does not represent a horizon intermediate between some two of these. It is a striking fact that but one of the twenty-nine species of eurypterids recorded from the five Silurian eurypterid horizons above the Lockport is known above or below the particular horizon in which it was discovered. Hence we cannot reasonably expect a distinct but closely related horizon, such as the Kokomo is believed to be, to contain species identical with any of the New York eurypterid horizons. In the writer's opinion, the Kokomo Eurypterid fauna represents a horizon of Salina age which is as yet faunally unknown in New York.

* Am. Geol., vol. vi, p. 259, 1890.