ART. XVIII.—*Remarks on the Age of the Goniatite Limestone at Rockford Indiana, and its relations to the "Black Slate" of the Western States, and to some of the succeeding rocks above the latter;* by F. B. MEEK and A. H. WORTHEN, of the Illinois State Geological Survey.

It is known to most of those who have studied the geology of the west, that there is an outcrop of limestone near Rockford, Indiana, usually termed the Rockford Goniatite bed, in regard to the age of which there is some difference of opinion amongst geologists. This rock is only exposed at a single locality in the bed of a small stream, where not more than a thickness of two feet of it is seen. It is a mottled brownish and ash-colored argillaceous limestone, and contains, in addition to the *Goniatites* from which it takes its name, other fossils belonging to the genera *Nautilus*, *Orthoceras*, *Pleurotomaria*, *Euomphalus*, *Spirifera*, *Rhynchonella*, &c.

No other rock is seen above or below this at the Rockford locality, but in sinking wells in that vicinity it has been ascertained that it rests upon a Black Slate forming a marked horizon

in several of the Western States. Owing to the fact that this slate has been seen to form the bed the same stream at another place about one mile above, and at a slightly higher elevation, it has been supposed that the Goniatite bed is intercalated in it, and the mystery has been that the fossils occurring in the limestone have a decidedly Carboniferous aspect, and in some instances have even been considered actually identical with well known European Carboniferous species; while the Black slate has been referred by Prof. Hall of Albany, New York, to the horizon of the Marcellus shale of the N. Y. series, occupying a position far down in the Devonian, at the base of the Hamilton Group.* In addition to this, Prof. Hall also refers a rather extensive series of fine arenaceous, and more or less argillaceous deposits, holding a position above the Black slate near Louisville, Ky., and at other localities in the west, to the Portage and Chemung Groups of New York, higher members of the Devonian, which are in New York overlaid by a great thickness of upper Devonian strata equivalent to the Old Red Sandstone, of the British geologists.

Without attempting to give a detailed statement of the opinions that have from time to time been expressed in regard to the age of the Black slate and overlying strata alluded to, we would remark that the most generally received opinion amongst western geologists has been, that the whole series known in Indiana and Kentucky as the "Fine-grained sandstone of the Knobs," down to the Black slate, should be included in the Carboniferous system, and some even include the latter also in the Carboniferous.

When the distinguished French geologist, DeVerneuil, was in this country in 1846, he made an excursion through the Western States for the purpose of studying our rocks, and obtained a fine collection of their characteristic fossils. After his return to Europe he published a highly interesting memoir on the parallelism of American and European formations, in which he referred all the fine arenaceous and shaly beds holding a position between the Black slate and the Carboniferous limestones in Indiana, Kentucky, and Tennessee, as well as a portion of the Waverly sandstone in Ohio, to the Carboniferous system. One of the *Goniatites* given to him by Dr. Owen from the Rockford limestone, he considered identical with *G. rotatorius* of Koninck, a well known Lower Carboniferous species, which led him to refer the limestone from which it was obtained to the lower Carboniferous. The Black Slate, however, he referred to the horizon of the Genesee slate of the New York series.†

* See Proceed. Am. As. Geol. and Nat., p. 267, vol. i; also Rept. 4 Dist. N. Y. Geol. Survey, p. 519.

† See Bulletin Geol. Soc. France, vol. iv, 2d Series.

After the publication of this paper, Prof. Hall was for a time inclined to concur, at least in part, with De Verneuil's views, but he subsequently returned to his former opinion, which he has continued to maintain, with his usual zeal and ability, to the present time. In an important paper recently published by him in the 13th Annual Report of the Regents of the University of New York, he describes a number of fossils from the Rockford Goniatite bed, along with others from the Marcellus shale in New York, and refers not only the Black slate, but the Rockford limestone, which has been supposed to be intercalated in it, to the horizon of the Marcellus Shale.

As the question in regard to the age of the Rockford goniatite bed has an important bearing on the parallelism of our rocks with established horizons elsewhere, we have, while investigating the fossils in the Illinois State Geological collection, carefully compared them with a series of specimens from Rockford, Indiana, in order to determine whether or not the Goniatite bed at that place is represented in our state, and if so, what relations it bears to our other rocks. These comparisons have led us to the conclusion that it is represented in Illinois, as well as in Missouri and Iowa, and that it holds a much higher stratigraphical position than that assigned it by Prof. Hall.

In the first place, we should remark that there is no evidence whatever, that the rock under consideration is overlaid at Rockford, or at any other locality, by any part of the Black slate, though we know the slate occurs beneath it there, as well as in Illinois.

Again after a careful study of a series of the Rockford fossils, we have clearly satisfied ourselves that the limestone from which they were obtained is of the same age as the Chouteau limestone of Prof. Swallow. The evidence of this is the positive identity of at least six of the 23 or 24 known Rockford species, with characteristic forms of the Chouteau limestone in Missouri and Illinois, while most of the others are either identical or closely allied. The following is a list of the species from Rockford which are known to be identical with Chouteau limestone species found in Missouri and Illinois, viz:—*Nautilus digonus*, Meek and Worthen, *Euomphalus lens*, Hall, *Rhynchonella Missouriensis*, Shumard, *Spirifera Cooperensis*, Swallow, (= *S. semiplicata*, Hall) *Cardiopsis radiata*,* Meek and Worthen, (= *Megambonia Lyoni*, Hall,) and *Sphenopterium enorme*, Meek and Worthen.

* We placed this species at first, provisionally, in the genus *Cardiomorpha* of Koninck, but suggested at the same time that we suspected it to be generically distinct. Later examinations have satisfied us of the correctness of this suggestion, and we have proposed to establish for its reception a new genus, under the name of *Cardiopsis*, from its resemblance to *Cardium*. It has no near relations to the type of the genus *Megambonia*.

In classifying the rocks of Missouri, Prof. Swallow, (and his assistants, including one of the writers) knowing that his Chouteau limestone holds the same position, and contains many of the same fossils found in beds elsewhere in the west referred by Prof. Hall to the Chemung group, placed it on a parallel with the Chemung, and Prof. Hall has also since referred equivalent beds in Iowa to the same horizon.

In order that the reader may understand more clearly the position of the Chouteau limestone with relation to our other western formations, we give below a section showing the order of succession of the several beds, beginning with the Burlington limestone, which is acknowledged by all to be Carboniferous, and extending down to the Hamilton Group inclusive:—

1.—Burlington limestone attaining a thickness of	-	200 feet.
2.—Chouteau limestone,	- - -	100 "
3.—Vermicular sandstone and shale,	- - -	65 to 100 "
4.—Lithographic limestone (rather local),		60 "
5.—Black Slate,	- - -	30 to 40 ft.*
6.—Hamilton group,	- - -	120 "

Numbers 2, 3, and 4 of this section were included by Prof. Swallow in the Chemung, though Prof. Hall thinks that at least a part of the Lithographic limestone, should be referred to the Hamilton group. It is true a few of the many fossils found in the Lithographic limestone resemble Hamilton forms, and one of them seems to be undistinguishable from *Orthis Vanuxemi*, of Hall, a common Hamilton group species. It is well known, however, that many of the other fossils found in this limestone occur in the Chouteau beds above, where they are sometimes mingled with Carboniferous forms. At the same time, unless the *Orthis* just mentioned is an exception, not one of the species occurring in the Lithographic limestone and the Chouteau beds above, can be, so far as our knowledge extends, positively identified with any of the numerous well marked Hamilton forms in the beds below the Black slate.

In regard to the occurrence of the *Orthis* which seems to be undistinguishable from *O. Vanuxemi*, in the Lithographic limestone, we would remark that we do not think it a fact entitled to much weight, when it is borne in mind that *O. Vanuxemi* is so very closely allied to the Carboniferous *O. Michilini* of L'Eveille, that even Mr. Verneuil regarded them as scarcely distinguishable, and the differences between them have not yet been clearly defined. Prof. Hall acknowledges that it "is so closely allied to *O. Michilini* of L'Eveille, that it is

* In some parts of Ky. and Indiana, the Black slate attains a thickness of about 100 feet.

very difficult to point out characters by which it may be distinguished." He thought, however, that, judging from DeKoninck's figures of *O. Michilini*, he could see some slight differences in the vascular impressions and dental processes, and remarked that the "minute granulations or punctæ upon the exterior surface [of *O. Vanuxemi*] present characters which are not noticed in the figures and descriptions [of *O. Michilini*] so far as I have observed."* Yet we find in Mr. Davidson's very carefully written description of *O. Michilini*, since published in his Monograph of the Carboniferous Brachiopoda of Scotland, that he says the surface is "covered with minute punctures." In fact almost every word of Mr. Davidson's description would apply equally well to *O. Vanuxemi*; and after a very careful comparison of our western form with authentic specimens of *O. Michilini* from Scotland, sent by Mr. Davidson, we have been unable to find any appreciable differences. We are not, however, contending that they really are identical, but we simply mean to say that it is unsafe to base conclusions upon such closely allied species.

The three subdivisions Prof. Swallow has called Vermicular sandstone and Shale, and the Chouteau limestone above, although often distinctly separable by their lithological characters, seem sometimes to replace each other, or often one is augmented in thickness at the expense of the other, though they are mainly characterized by the same fossils. The whole group is very variable in its lithological characters, the very same beds that are at one place composed of hard bluish or ash-colored compact limestone, being at others a yellowish very fine soft argillaceous, or arenaceous rock, or consisting of alternations of brownish and greenish shaly limestone, &c. The fossils are usually in a better state of preservation in the limestones than in the other beds, and assume a more decided Carboniferous aspect than in the arenaceous and argillaceous strata, even where the latter occur above the limestones.

The Black slate, so far as our knowledge extends, seems to be nowhere greatly developed in Missouri, though it is probably represented at Hannibal in that state by six feet of blue shale beneath the Lithographic limestone, as may be seen by Prof. Swallow's Section No. 15, p. 99, of the Missouri Report. Some eight or ten miles east of Hannibal, in Illinois, it is seen occupying the same position with relation to the Lithographic limestone, and attaining a thickness of thirty or forty feet.

Although the position of the well marked Hamilton beds with relation to the representative of the Black slate, have probably not been very clearly determined in Missouri, they are there

* Tenth Ann. Rept. Regents University of N. Y., p. 136.

known, as Prof. Swallow has shown, to hold a position beneath the Lithographic limestone. In Illinois, however, numerous exposures show that the black slate comes in just above all the well defined Hamilton Group beds as may be seen by the following section taken near Jonesborough, Union county, Illinois:—

1. Brown silicious shale probably representing the Vermicular sandstone and Shale of Prof. Swallow,	50 to 60 ft.
2. BLACK SLATE with its characteristic <i>Lingula</i> ,	40 to 50 ft.
3. HAMILTON GROUP, consisting of a dark limestone, containing <i>Phacops bufo</i> ? <i>Strophomena Hamiltonensis</i> , <i>Trepidoleptus carinatus</i> , <i>Heliophyllum Halli</i> , and other well known Hamilton species, along with <i>Atrypa reticularis</i> , &c.,	120 ft.

Now as the Chouteau limestone of Prof. Swallow, is known to hold a position immediately beneath the Burlington limestone, and considerably above the horizon of all the Hamilton group beds of the West, as well as above the Black slate, which also overlies the Hamilton group in Illinois, it follows as a matter of course, that its representative in Indiana, the *Goniatite* bed at Rockford, cannot belong to any part of the Marcellus shale, lying at the base of the Hamilton group.

Again, the fact that all our well marked Hamilton beds in Illinois, hold a position beneath the Black slate, while in New York, as already stated, the Marcellus shale lies at the base of the Hamilton Group, renders it very improbable that even our western Black slate formation represents the Marcellus shale. Its position would seem to be more nearly that of the Genesee slate of New York, as suggested by M. DeVerneuil, which supposition is strengthened by the affinities of the only fossils yet found in it, viz,—a small *Lingula* and a *Discina*, scarcely, if at all, distinguishable from species occurring in the Genesee slate of New York, to which in fact they were referred by Prof. Yandell and Dr. Shumard in 1847.

Although Prof. Hall describes about twenty species of fossils from the Rockford *Goniatite* bed, it will be observed that he does not identify any of them, with Marcellus shale species, or with forms occurring in any other part of the Hamilton group either in New York or in any of the Western States; but refers the rock in which they occur to the horizon of the Marcellus shale, solely from the fact that it was thought to be intercalated in the Black Slate, and from the supposed affinities of its *Goniatites*, to Marcellus species. Aside, however, from the evidence we now have that the Rockford limestone is of the same age as the Chouteau limestone of Missouri, which comes in some distance above

the Black slate, and is exactly equivalent to beds referred by Prof. Hall at Burlington, Iowa, to the Chemung, its whole group of fossils including the *Goniatites*, strike us as being more nearly allied to Carboniferous forms than to those of any of the New York rocks.

If we take for instance the three species of *Goniatites* now known from the Rockford bed, we find first that *G. Lyoni*, Meek and Worthen, (= *G. hyas* of Hall,) which Prof. Hall compares with *G. Chemungensis*, of Vanuxem, differs materially from Vanuxem's figure of that species, in having but two lobes in each septum visible on either side, while *G. Chemungensis* is figured as having five. It bears no near analogy whatever, to any of the species figured by Prof. Hall, from the supposed equivalent bed in the Marcellus shale of New York.

Again *Goniatites Oweni* of Hall,* is much more closely allied to *G. princeps* of Koninck, (a European Carboniferous species) than it is to any of those yet known from the Marcellus shale, or any other rock in New York. It agrees in size and form with Koninck's species, as well as in having constrictions at intervals left upon its internal cast by the occasional thickening of the lip, while it presents but slight differences in the lobes of its septa; the most obvious difference being in the length of its dorsal lobe, which is more attenuated than in *G. princeps*, though even in this character, the Rockford specimens vary to some extent. It is true *G. princeps*, as figured by Mr. Koninck, is marked by regular costæ, while *G. Oweni*, as we usually see it in the condition of worn casts, seems to be smooth. We have, however, seen unmistakable traces of similar costæ, on some of the Rockford specimens. We are not contending, however, for the absolute specific identity of these forms, but we do maintain that the analogy of the Rockford species to *G. princeps* is much nearer and more striking than its relations to any of the Marcellus shale species.

The third species, *Goniatites ixion* of Hall, while it presents but very remote analogy to any of the Marcellus shale species, is scarcely, if at all distinguishable from the Carboniferous species, *G. rotatorius*, of Koninck,† with which Mr. Verneuil considered it identical. They may possibly belong to different species, yet the minute differences pointed out by Prof. Hall, are, we think, not inconsistent with specific identity in a genus like this. Every one who has studied the *Ammonitidæ* must be aware how unsafe it is to base specific distinctions on minute differences in the smaller details of the lobes of the septa, or upon slight differences in the size of the umbilicus. We are

* See thirteenth Ann. Report Regents University New York, p. 100.

† Animaux Foss., pl. 61, fig. 1.

not insisting, however, upon the exact identity of these forms, for that is a question that can only be settled by direct comparison with authentic specimens of the European species; yet that they are at least strikingly analogous, must be evident to any one who will but glance at Prof. Hall's, and Prof. DeKoninck's figures.

If we compare the two species of *Nautilus* now known, from the Rockford beds, *N. digonus*, and *N. trisulcatus*, Meek and Worthen, we find them wholly unlike any forms known in the Marcellus shale, while the latter species is allied to the Carboniferous *N. sulcatus* of Sowerby, (see Koninck's An. Foss., pl. xlvii, fig. 10), and the former is analagous to two or three of the species figured by DeKoninck from the Carboniferous rocks of Belgium. In fact both of these species belong to a peculiar subgenus of *Nautili* for which we have proposed the name *Trematodiscus*, a group embracing a number of discoid Carboniferous species, with a wide perforated umbilicus and narrow whorls, which are ornamented with longitudinal angular ridges, and sometimes with parallel striæ. So far as we know, the entire group is confined to the Carboniferous system, unless those found in the Rockford *Goniatile* bed and its equivalent in Illinois, are exceptions.*

In order to show the close relations between the Chouteau limestone and the Burlington (acknowledged Carboniferous) beds above, in Illinois, we might give many sections, with lists of fossils, but the following taken near Grafton in Jersey county, will be sufficient for illustration:—

1.—BURLINGTON LIMESTONE,

presenting its usual characters and containing its usual fossils; showing at the immediate outcrop where the section was taken, a thickness of 8 to 10 feet, but increasing as the country rises back to a thickness of 150 or 200 feet.

2. CHOUTEAU LIMESTONE.

Upper part consisting of ash-colored argillaceous shelly limestone in thin laves, with greenish marly partings and calc spar concretions. Containing *Cyathozina* (undt. sp.), *Poteriocrinus Meekinus*, *Actinocrinus* (undt. sp.), *Spirifer peculiaris*, *S. grimesi*, *Athyris Prouti*, *A. Hannibalensis*, *Strophomena rhomboidalis*, *Orthis Michilini*, *O. resupinata*, *Productus semireticulatus*? *Platyceras equilatera*, - - - - - 40 feet.

* The forms included in this subgenus differ so widely from the recent typical species of *Nautilus*, that few conchologists would place them in the same genus if they were found living in our present seas. It includes such species as *N. pingius*, *N. stygialis*, *N. Edwardsianus*, and *N. Omalianus* of Koninck, and *N. sulcatus*, and *N. cariniferous* of Sowerby. *Gyrocerus gracile* of Hall, from the Rockford limestone probably also belongs to this group.

Lower beds, composed of brownish-buff colored argillaceous limestone, with nodules of calc spar, the upper part being in thicker beds than the lower which has a more greenish tinge. Fossils—*Strophomina rhomboidalis*, *Chonetes ornata*, *Cardiopsis radiata*, *Productus semireticulatus*? *Cyrtoceras* and *Gomphoceras* (undt. sp.) *Nautilus digonus*, a discoid *Goniatite*, and a *Proetus* (undt.)

	-	-	60 feet.
3.—Black slate shading upwards to greenish shale,	-	-	40 "
4.—Hamilton group, consisting of dark limestone,	-	-	10 "
5.—Niagara group limestone of buff col.,	-	-	100 "

Of the fossils mentioned in the above section the following are usually characteristic of the Chouteau series:—*Cyathoxina* (undt.), *Poteriocrinus Meekianus*.* *Spirifera peculiaris*, *Athyris Prouti*, *A. Hannibalensis*, *Chonetes ornata*, *Cardiopsis radiatus*, *Nautilus digonus*, and an undetermined *Goniatite*. Those usually regarded as strictly Carboniferous are,—*Spirifera Grimesi*, *Orthis Michilini*, *Productus semireticulatus*, and *Platycerus equilatera*.

The forms common to Carboniferous and Devonian rocks, are *Strophomena rhomboidalis*, and *Orthis resupinata*. The species here enumerated, however, are only those collected at the locality where this section was taken. Several other Carboniferous forms are sometimes found in the Chouteau beds at other places, and a number of other Chouteau species are known to range up into the Burlington beds. From a locality in an adjoining county, we have an *Actinocrinus*, from the Chouteau series, which we can only distinguish as a variety, from the well known Burlington *A. pyriformis* of Shumard; and along with it we also find a species of a peculiar coral (*Sphenopoterium enorme*) described by us from the Rockford *Goniatite* bed.

In an interesting and important paper on the rocks and fossils of Burlington, Iowa, published by Mr. Charles A. White of that place, in the Boston Journal of Natural History, (vol. vii, p. 209) he shows that out of a list of one hundred and two described species occurring in the Burlington limestone, fifteen commenced their existence in the beds below, referred by Prof. Hall to the Chemung; which as is well known, represents the Chouteau limestone of Prof. Swallow.

When we thus find these beds so intimately connected by the general affinities of their organic remains, as well as by the actual mingling of species with the undoubted Carboniferous rocks above, and bear in mind that the Chemung group in New York and Pennsylvania, is surmounted by another Devonian formation, (the Old Red Sandstone) between two and three thousand

* At the time Dr. Shumard described this crinoid, its exact geological position was not known, the specimen having been found loose at the base of a bluff composed in part of the Chouteau beds, and partly of the Burlington limestone. Its true position has since been determined to be in the Chouteau limestone, though it probably also ranges up into the Burlington limestone in some places.

feet in thickness, the questions naturally suggest themselves,—are we right in referring these Chouteau beds to the horizon of the Chemung? Can it be possible that a great formation like the Old Red Sandstone, characterized by the remains of a peculiar fauna of its own, is wanting here between the Chouteau and Burlington limestones?

But on the contrary, it may be said, if we do not adopt this conclusion, what are we to do with the fossils occurring in these rocks apparently identical with Chemung species? In reply to this latter question, we would state that although we have for a long time thought a few species occurring in the Chouteau beds identical with Chemung forms, later comparisons with New York specimens from the latter formation, lead us to doubt their actual specific identity. They are generally obscure casts of *Avicula* and other lamellibranchiate mollusca, some of which also resemble Carboniferous species. Admitting, however, that they are undistinguishable from Chemung species, does their presence here in the same beds with numerous other fossils totally distinct from Chemung forms, and not only more nearly allied to Carboniferous species, but in some instances identical with those occurring in acknowledged Carboniferous strata above, warrant us in placing these beds on a parallel with the Chemung group?

Mr. White, in discussing this question in his paper already cited above, says, "admitting that some of the species found in the lower beds have been identified with those of the Chemung group of New York, it settles beyond question their geological equivalency, but does not necessarily prove that they were contemporaneous. Indeed, it seems probable that they were not so, by an interval of time that it would take the species to migrate that distance. May it not, therefore, be inferred that the species originated at the east, and were migrating westward during the time that the bottom of the Chemung seas was sinking, and receiving upon it the deposit of the Old Red Sandstone,—thus making these Devonian rocks equivalent to the Chemung of New York, and contemporaneous, at least in part, with the Old Red of the Katskill Mountains?"

If any of the species found in the strata under consideration are really identical with Chemung forms, as has been supposed, Mr. White's suggestion that they had prolonged their existence by migrating westward, until long after the close of the Chemung epoch in New York, is not improbable, but in that case, we should not refer the rock in which they occur to the Chemung, but either to the Old Red, or to the Carboniferous, for in using any of these names we refer to a period in time, as well as to a group of strata. The entire group of fossils, however, found in these beds is far more nearly allied to the Carboniferous fauna than to that characterizing the Old Red either in this country or

in the Old world ; in short we know of nothing in this formation bearing any analogy to the fossils of the Old Red sandstone.

In conclusion, we would remark that the relations between the Chouteau and Burlington limestones in Missouri, Iowa, and Illinois, where both occur together, as well as the affinities of the fossils found in the former in the states mentioned, and at Rockford, Indiana, show that it should probably be referred to the Carboniferous system ; or, at any rate that it is much more recent than the Chemung, and not equivalent to any New York rock.

It is not improbable, however, that the Portage and Chemung groups may be represented between the Chouteau limestone and the horizon of the Black Slate, at some places in the Western States alluded to, but if so, their presence there has yet to be clearly demonstrated.

amounting to 400—500 grammes, and should not hesitate to employ still larger ones. It is however more convenient to use the above quantity, and replace the material as fast as exhausted.

The facility with which nitrate of ethyl can be obtained by the above process must, I think, give it a decided advantage over the iodid of ethyl for the preparation of the ethyl bases, in the manner which I described in the last number of this Journal. The lower equivalent of nitric acid as compared with iodine is a matter of considerable importance, one hundred parts of iodine are capable of holding in combination something less than 23 of ethyl, whereas one hundred parts of nitric acid combine with over 53 of ethyl; a material point as the iodine on the one hand and the nitric acid on the other are merely the vehicles for bringing about the ethyl-substitution. In operations in pressure tubes where space is valuable, this is an important consideration; in an economical point of view also, the advantage appears to be greatly on the side of the nitrate of ethyl.

NITRITE OF ETHYL.

The action of nitric acid on alcohol in the preparation of nitrite of ethyl may be conveniently moderated by protosulphate of iron, and the nitric acid reduced by that agent instead of at the expense of part of the alcohol. The proportions which I have used are, nitric acid sp. gr. 1.37, 90 cc., alcohol of 90 per cent, 150 cc., ferrous sulphate 45 grammes. The product is very large, the distillate on being shaken up with water yields more than half its bulk of nitrite of ethyl. The latter is not perfectly free from aldehyd, but more so than that obtained by some other processes. The action is perfectly quiet to the last, and the distillation may be carried on rapidly.

2. *On the Effects of Reducing Agents upon Nitrite of Ethyl.*

As ammonia under the influence of oxydizing agents is burned to nitrous and nitric acids, so these acids when acted upon by reducing agents, might naturally produce ammonia, or in the presence of a decomposing ethyl compound, might give rise to the formation of substituted ammonias. The experiment however seems to prove that while ammonia is a constant result of this reduction, it varies greatly in quantity according to the particular reducing agent employed, and that substituted ammonias are not produced, at least not in recognizable quantities. The following were the reactions observed :—

Reduction by protochlorid of tin.—Alcoholic solution of protochlorid of tin added to nitrite of ethyl causes violent effervescence, but no disengagement of nitrous fumes. The solution of

protochlorid was added until reaction ceased. The whole was then distilled with caustic potash and the resulting gases conducted into dilute chlorhydric acid, which by evaporation left only a film of substance—this gave on examination distinct indications of ammonia.

Reduction by sulphydric acid.—A large quantity of sulphydric acid was conducted through nitrite of ethyl. Slight effervescence was produced and much sulphur deposited. The liquid filtered from the sulphur proved to contain a large quantity of ammonia, but no ethylamine, di-, or tri-ethylamine, although the mode of examination employed would have detected a very small quantity if present. After the removal of the ammonia, the solution heated with Pt Cl_2 gave a small quantity of a brown precipitate of a platinum salt, which when heated glowed for a long time showing the presence of much carbon, and finally left a residue of reduced platinum. The amount obtained was too small for investigation, but 20 or 25 milligrammes of Pt. salt were obtained from the decomposition products of 50 grammes of nitrite of ethyl.

This result therefore, as far as to the production of ammonia, corresponds with that obtained by M. Emile Kopp,* although, as that chemist employed sulphurate of ammonia instead of sulphydric acid, it does not appear that the production of ammonia by the reaction itself, could be positively established.

Reduction by ferrous acetate.—Nitrite of ethyl was added to about three times its bulk of ordinary acetic acid, and sufficient alcohol to make them mix. To this mixture iron filings were added. A powerful action set in without aid of heat. Deutoxyd of nitrogen was evolved in considerable quantity. When action had ceased, the resulting liquid was filtered, evaporated with chlorhydric acid and distilled with caustic potash. The distillate contained only traces of ammonia.

The effect of the reducing agents on nitrite of ethyl is therefore very different. Only with sulphydric acid was any considerable quantity of ammonia produced, and only with ferrous acetate was deutoxyd of nitrogen evolved.

3. *On the Preparation of Urea from Ferrocyanid of Potassium.*

In the preparation of urea by Wöhler's method the amount obtained always falls short of that which should theoretically be produced. Having remarked that even when the operation is

* Gerhardt, *Chimie Org.*, ii, 347.

carefully performed with Liebig's proportions, the lixivate always contains undecomposed cyanid of potassium, it occurred to me to try the effect of a more thorough oxydation, and the result proved very favorable. The following was the course adopted.

Of roasted ferrocyanid of potassium 850 grammes are mixed with 318 grammes of thoroughly dried carbonate of potash in grains, and fused in an iron vessel. When decomposition is complete, the vessel is a little cooled and 1900 grammes of red lead are to be added, not all at once, but 300 to 400 grammes at a time, with intervals of 10 minutes, stirring and keeping up heat enough to retain the whole in a state of fusion.

After the last addition of red lead the mixture is suffered to remain half an hour on the fire to complete the reaction. Heat is applied in all for about four hours. In this way the cyanid of potassium becomes thoroughly oxydized. The process is concluded in the usual manner, and 500 grammes of urea are obtained. No particular precaution is necessary during the fusion, or even the lixiviation with cold water, but in evaporating the solutions the greatest care must be taken to carry off the vapors.*

Philadelphia, April, 1861.