ART. XV.—*The Russian Carboniferous and Permian compared with those of India and America. A Review and Discussion*; by CHARLES SCHUCHERT.

[Continued from p. 46.]

PART III. THE WORK OF DIENER.

1. *The Permocarboniferous Fauna of Chitichun No. I.* Mem. Geol. Surv. India, ser. xv, Himálayan Fossils, vol. i, pt. 3, 1897, pp. 1-105, pls. i-xiii.
2. *The Permian Fossils of the Productus Shales of Kumaon and Gurhwal.* Ibid., pt. 4, 1897, pp. 1-54, pls. i-v.
3. *Permian Fossils of the Central Himálayas.* Ibid., pt. 5, 1903, pp. 1-204, pls. i-x.

In the central Himalayas at the limestone crag of Chitichun No. 1, at an elevation of 17,700 feet, Griesbach, Middlemiss, and Diener, in the year 1892, discovered a lot of fossils described in the work cited above (1). The stratigraphical results of this collection are described by Diener on pp. 85-105, from which are taken the following extracts:—

“Karpinsky and Tschernyschew, two authors to whom the most detailed studies of the Artinskian fauna are due, strongly advocate the distinction of the permocarboniferous from carboniferous and permian systems, and are decidedly averse to uniting it with either the one or the other. Tschernyschew especially strongly combats the view of the majority of geologists who proposed to unite the permocarboniferous with the permian, as a lower division of the system. According to him a separation of the permocarboniferous from the permian system is demanded by the general aspect of the fauna, in which the carboniferous types greatly predominate, chiefly among the brachiopods. If it ought to be united either with the carboniferous or permian system, in spite of its distinctly intermediate position, it must necessarily be placed in the former, on the strength both of the carboniferous character of its fauna and of historical priority, since the Artinskian sandstone had been correlated with the carboniferous millstone-grit of Western Europe by Sir Roderick Murchison, who first introduced the name permian.

“Against the first argument the objection may be raised that notwithstanding the prevalence of carboniferous types in the Artinskian fauna, the latter ‘marks a very important moment in the history of development of organic remains, namely, the first appearance of true ammonites with complicated sutures.’ Nor is the large percentage of carboniferous types in the Artinskian fauna an astonishing fact, in view of the absence of any break in the sequence of marine beds from the upper carboniferous to the true permian strata. Even in beds, which must be placed very high in the permian system, in the upper Productus limestones of the Salt Range and in the Oto-

ceras beds of Julfa, the fauna contains a proportionately large number of carboniferous forms. It is to the faunas of these deposits, the normal representatives of the pelagic permian [by this the author means a *normal* marine fauna], not to the local fauna of the Zechstein, that the permocarboniferous fauna must be compared, if we want to get a clear idea of its relationship to those of the upper carboniferous and permian. Bearing in mind the gradual passage from an upper carboniferous to a permian fauna through the intermediate group of rocks, the question to be answered is, which consideration is of the greater importance in defining the boundary between the two systems, the appearance of a new group of cephalopods, which become of an unparalleled stratigraphical value in mesozoic times, or the presence of a belated fauna, composed of forms which are generally not well adapted for the characterization of narrowly limited horizons.

"The majority of geologists have decided in favour of the first alternative. Gümbel, Krassnopolssky, Kayser, Waagen, Credner, Munier-Chalmas and A. de Lapparent, Frech—to enumerate only a small number among them,—are unanimous in regarding the permocarboniferous as the lowest division of the permian system" (pp. 87–88).

"In the Mediterranean region three different rock groups have yielded fossil remains of this pelagic development of the permian epoch. These rock groups are the Fusulina limestones of the valley of Sosio in Sicily, the Bellerophon limestone of South-eastern Tyrol and Friaul, and the Otoceras beds of Julfa in Armenia. All of them are of a rather isolated occurrence and, as far as one may judge from their faunas, of different age.

"The lowest position is apparently held by the Fusulina limestone of Sicily. Its cephalopod fauna seems to be more nearly related to the Artinskian one than to those of the Jabi beds of the Salt Range or of the Otoceras beds of Julfa. Ammonites with ceratitic sutures are yet absent. According to Karpinsky's statement, one species of *Medlicottia* is identical with an Artinskian form; ten more species are very nearly allied. On the other hand, Karpinsky and Waagen noticed the first appearance of *Waagenoceras* and *Hyattoceras* in Sicily, two genera which show a much more complicated sutural line than any of the Artinskian *Ammonia*. Waagen consequently places the Fusulina limestone of Sicily on a higher level than the permo-carboniferous stage, but on slightly lower level than the Jabi beds of the upper Productus limestone. . . .

"The Otoceras beds of Julfa with their strongly marked triassic affinities must certainly be higher in the upper palæozoic series than the Fusulina limestone at Sosio. They cannot be much different in age from the Otoceras beds of the Him-

alayas, although the latter certainly hold a somewhat higher stratigraphical position, and they may consequently be placed on a level with the upper *Productus* limestone or with the Chidru group of the Salt Range.

"The youngest of the three rock groups is probably the Bellerophon limestone of South-eastern Tyrol. Its fauna is a very peculiar one, species identical with those known outside this rock group being almost completely absent. The predominance of palæozoic types induced Stache to fix the homotaxis of these beds as upper permian, whereas Gümbel supposed them to be of lowest triassic age. . . .

"In none of these three permian rock groups of the Mediterranean region is a normal sequence of marine beds exposed, with the possible exception of the Bellerophon limestone of the Carnian Alps, which, however, is underlaid by an enormous mass of unfossiliferous limestones and dolomites. Their correlation must consequently be based on palæontological evidence alone" (pp. 90-91).

Recently, Schellwien and Kossmat (Monatsber. No. 9, Deutsch. Geol. Gesellsch., 1905, pp. 357-9) found in the Bellerophon limestone (usually regarded as the topmost Permian of the Alps) of Krain, west of the Laibach plain, a fauna consisting in the main of brachiopods, corals, and Foraminifera. As yet the fossils are not worked out of the matrix, but the following species are determined: *Richtofenia* aff. *lauerenciana*, *Productus indicus*, *P. abichi*, *Marginifera ovalis*, and *Lonsdaleia indica*. In regard to these fossils Schellwien concludes as follows:—

"The finding of this fauna dispels all doubt as to the Permian age of the Bellerophon limestone. The value of this discovery in fixing the time position of this limestone, however, is overshadowed by the greater one,—that of fixing the chronologic position of the *Productus* limestone [of India], the correlations of which, as is known, are still at variance. The fossil-bearing beds of the Bellerophon limestone are everywhere in close association with the lower Werfen beds [Triassic]: in southern Tyrol the boundary between the Werfen deposits and the Bellerophon limestone is difficult to establish. At Krain the fossiliferous zones of the Bellerophon limestone are also separated, but by a thin dolomite series from the Trias. These upper dolomites introduce micaceous layers and gradually pass into the Werfen slates, with their well-known bivalve fauna. The Bellerophon limestone, therefore, can represent only the highest zone of the Permian, and for the *Productus* limestone the same view may also be affirmed. Worthy of note is the fact that of this fauna of the Bellerophon limestone, it is also not only those of the higher zones of the Indian *Productus* limestone but likewise forms of the

lower horizons. Should the detailed examination show that the fossils of the various horizons of the *Productus* limestone are also found associated in the thin fossiliferous zone of the *Bellerophon* limestone of Krain, the conclusion will be unavoidable that the various zones of the *Productus* limestone are of Upper Permian age."

In the second paper cited above, treating of the fauna of the *Productus* shales, Diener states the following:—

"The only decisive evidence for a permian age of the *Productus* shales is however based on their stratigraphical relations to the triassic beds of the mesozoic belt of the Central Himalayas, not on their fossil remains. One of the chief results of Griesbach's geological survey of the Bhot Mahals of Kumaon and Gurhwal is the proof of an unconformity, existing at the base of the *Productus* shales, which locally overlap successive strata of carboniferous age. With this unconformity another uninterrupted sequence begins, with conformable bedding throughout, which ranges from the *Productus* shales to the topmost beds of the triassic system. So intimate is the stratigraphical connection between the *Productus* shales and the following *Otoceras* beds of lowest triassic age, that a sharp boundary cannot be drawn between them" (pp. 53-54).

In the third publication above cited, Diener reviews his former work on the fossils of Chitichun No. 1, owing to larger and more significant collections subsequently made by Walker. These collections have not altered Diener's correlations with the Salt Range, but they have, when interpreted in the light of Noetling's publications, caused him to depart strongly from the nearly unanimous views of European stratigraphers and to agree in the main with the intercontinental correlation of Noetling. Great weight should be attached to the correlation of these two paleontologists, for they have collected the fossils of the Permian in India and studied them in the laboratory. Diener's conclusions are as follows:—

"So far there is no reason for any change in my correlation of the Chitichun fauna with Indian faunæ of permian age, as proposed by myself in 1897. I am, however, bound to confess that the affinities of the Chitichun fauna to those of Europe have not been correctly interpreted, and that my examination of Walker's materials is apt to lead in this respect to results remarkably different to those deduced in my first memoir.

"In that memoir [here numbered 1] the conclusions at which I arrived with regard to the stratigraphical position of the Chitichun fauna were summed up as follows:—

"The Chitichun limestone is approximately homotaxial with the upper division of the middle *Productus* limestone (Virgal and Kalabagh beds) in the Salt Range. It probably corresponds in age to the permo-carboniferous horizon (Artin-

skian stage) in Russia, but the description of the Brachiopoda from the Fusulina limestone of Sicily must be awaited before it is possible to decide whether it does not hold a slightly higher position in the stratigraphical sequence than the Artinskian deposits.’”

“This mistake of correlation is the legitimate outcome of an erroneous interpretation of the stratigraphical position of the Salt Range *Productus* limestone. The supposition ‘that the entire *Productus* limestone forms a series, which cannot be separated from the carboniferous system and that the Fusulina-bearing Amb beds certainly belong to the latter,’ was not my fault. I followed the majority of European palæontologists in this, and my error was due to the ignorance of the leading palæontologists as to the right means of correlating rock-equivalents of anthracolithic age in Europe and in India.

“Waagen believed the *Productus* limestone to be permian, but to represent the entire permian system. He consequently correlated the lower *Productus* limestone and the Katta beds of the middle *Productus* limestone with the Artinskian stage of Russia, considering them as permo-carboniferous. The palæontological investigations of Nikitin, Frech and Tschernyschew raised doubt as to the validity of this correlation. The affinity of the fauna of the lower *Productus* limestone to those of the upper carboniferous rocks of Russia and the Ural Mountains and of the Carnian Fusulina limestone of the Eastern Alps induced Rothpletz (*Palæontographica*, vol. xxxix, p. 63), Frech (*Die Karnischen Alpen*, p. 372), Oldham (*Manual of the Geology of India*, 2nd edn., p. 125), and Suess (*Denkschr. kais. Akad. d. Wissensch. Wien, math. nat. Cl.*, vol. lxi, p. 439) to correlate the lower *Productus* limestone with the upper carboniferous rather than with permo-carboniferous beds. In the meantime Tschernyschew called attention to the strongly marked affinities of the faunæ of the middle *Productus* limestone and the Artinskian stage. On palæontological grounds he tried to prove that the entire middle *Productus* limestone ought to be synchronised with the Artinskian strata of Russia.

“In admitting this homotaxis I merely followed the almost unanimous judgment of European geologists. The equivalence of the Chitichun limestone to the Virgal and Kalabagh beds in the Salt Range having been clearly demonstrated, the necessity of correlating it with the Artinskian stage of Russia was obvious.

“I have been convinced of the incorrectness of this correlation both by the recent reports of Dr. Noetling on the classification of the *Productus* limestone and of the Ceratite formation in the Salt Range, and by my own examination of the fossil materials collected by Walker” (pp. 53–54).

“I do not, however, believe that the Chitichun limestone

should be placed on a level with the *Fusulina* limestone of Sicily. So far as it is possible to judge from its Cephalopoda, the Chitichun fauna appears to be geologically younger. Ammonites with ceratitic sutures such as *Xenaspis carbonaria*, or with complicated sutures, such as *Cyclolobus Walkeri*, speak clearly in favour of a homotaxis of the Chitichun limestone with true upper permian strata of Europe" (p. 57).

"The evidence afforded by the two species of ammonites which were collected by Walker, together with Noetling's discovery of the true horizon of *Xenaspis carbonaria* in the *Productus* limestone of the Salt Range, is sufficiently strong to affect my view as to the correlation of the Chitichun limestone with permian beds of other countries, and obliges me to consider the latter as about homotaxial with the permian rocks of Timor and as slightly younger than the Sosio limestone of Sicily. I am therefore compelled to admit the correctness of Noetling's statement that there is at present no proof of the existence of a fauna of Artinskian age in the Himalayas" (p. 58).

Diener then takes up the "Correlation of the Anthracolithic System in Spiti with the Carboniferous and Permian Systems in Europe and India."

"Wherever in Spiti a complete series of the anthracolithic system is developed and well exposed, *two groups* can be recognised and distinguished, as has been stated by Hayden. Both groups are separated by a great *unconformity*, and differ remarkably in their faunistic character and in their lithological features.

"The group above the great unconformity, which corresponds to the *Productus* shales of the Niti area, is much better known than the lower division, because richer collections of fossils have been examined" (p. 193).

"The fossils to which the greatest stratigraphical importance must be attributed are the ammonites of the two genera *Cyclolobus* and *Xenaspis*. The presence of a species which is most nearly allied if not actually identical with *Cyclolobus Oldhami*, Waag., and the frequent occurrence of representatives of the genus *Cyclolobus*, speak very strongly in favour of a correlation with the upper *Productus* limestone of the Salt Range. In the Salt Range *Xenaspis carbonaria* is, according to Noetling, restricted to one single horizon only, namely, to the top beds of the middle *Productus* limestone" (p. 195).

"As faunistic elements of special interest in the Kuling shales of Spiti, *Grypoceras* sp. ind., *Myophoriopsis Krafftii* and *Spirigera* cf. *protea* var. *alata* may be quoted. The first and second are remarkable for their decidedly triassic affinities, the third belongs to a group of forms which has hitherto been recorded only from the permian rocks of Djulfa" (p. 196).

"Our knowledge is much more scanty with regard to the lower series of the anthracolithic system in Spiti, which is situated below the great unconformity.

"According to Hayden, the total thickness of this series is not less than 5,000 feet in the section above Lio on the Lipak river, where the sequence of the beds is most complete. Two fossiliferous horizons only have been discovered in this mighty sequence" (p. 198).

The fossils of the "upper horizon," or the *Fenestella* beds, are not stratigraphically significant, and the little there, considered in connection with the fauna of the lower beds, is rather in favor of regarding it as of Lower Carboniferous age.

In the lower flaggy limestone horizon (8a of Griesbach) the fossils are "unfortunately, scarce, generally ill preserved, and of a rather indifferent character." Diener thinks the age of the fossils is "more in favor of an upper carboniferous age," but his evidence is completely shattered in the appendix to his work, in a "Note on *Spirifer Curzoni*, Diener. By H. H. Hayden, Geological Survey of India." This author shows in the most convincing manner that the original generic identification of Diener was correct and that the species is to be called *Syringothyris curzoni*. A careful examination of Mr. Hayden's note, his illustrations, and those of Diener, will convince any American student of the Brachiopoda that the form in its general expression and size is to be compared with American forms low down in the Lower Carboniferous series. In further support of this lower Lower Carboniferous suggestion may be cited *Spirifer* cf. *strangwaysi* comparable to American *S. forbesi*.

Therefore it would seem that the entire 5,000 feet of material beneath the great unconformity may be Lower Carboniferous. The lower portion is certainly so and apparently nearly basal Lower Carboniferous.

PART IV. THE WORK OF GIRTY IN THE TRANS-PECOS REGION OF TEXAS.

1. *The Upper Permian in Western Texas*. By George H. Girty. This Journal, Nov., 1902, pp. 363-368.

2. *Report of a Reconnaissance in Trans-Pecos Texas*. By G. B. Richardson. Univ. Texas Mineral Surv., Bull. 9, 1904, pp. 32-45. Fossils determined by G. H. Girty.

3. *The Relations of some Carboniferous Faunas*. By George H. Girty. Proc. Washington Acad. Sci., vii, 1905, pp. 1-25.

The work of this paleontologist on the Carboniferous and Permian of southwestern Texas is best summarized in tabular form, the data being taken from his three papers on the subject.

Beginning with the highest beds, the facts are as follows:—

Guadalupian.

Capitan Limestone.

Above the Guadalupian or Capitan limestone there seemingly follows an unconformity of considerable extent. Then follow beds of gypsum, a white magnesian limestone, and a sandstone the age of which is unknown but apparently is best referred to the Triassic.

A massive white limestone. At least 1800 feet thick. Top not seen.

From the middle of this limestone comes a fauna, nearly all of which is new.

Fusulina elongata, *Acanthocladia*, *Goniocladia*, *Geyerella*, *Orthothetina*, *Productus popei*, *P. mexicanus*, *Spirifer mexicanus*, *Squamularia* (?) *guadalupensis*, *Spiriferina billingsi*, *Hustedia meekana*, *Pugnax swallowiana*, *Rhynchonella* (?) *indentata*, *Leptodus* (= *Lyttonia*), *Richthofenia permiana*, *Myoconcha*, etc.

Delaware Mountain Formation.

Essentially sandstone and limestone. Maximum thickness about 2300 feet.

At the base, in black limestone, occur: *Enteleles*, *Meekella*, *Hustedia meekana*, *Pugnax*, *Richthofenia permiana*, *Foordiceras*, and other ammonoids.

Higher up in the sandstone occur: *Fusulina elongata*, *Productus* cf. *subhorridus*, *Leptodus* (= *Lyttonia*), *Richthofenia permiana*, *Laevidentalium canna*, etc.

In the limestone occur: *Fusulina elongata*, Bryozoa of Mesozoic type, *Chonetes permianus*, *Hustedia meekana*, *Rhynchonella bisulcata*, *Leptodus* (= *Lyttonia*), *Richthofenia permiana*, and ammonites.

Hueconian or Pennsylvanian.

Mainly massive limestone with local shales and sandstones. Maximum thickness at least 5000 feet, more than 2000 feet of which are limestone.

Near the base occur: *Triticites*, *Productus cora*, *Marginifera* cf. *wabashensis*, *Reticularia perplexa*, *Spirifer rockymontanus*, etc.

Near the top occur (those marked "1" are Ural and "2" Indian types): *Fusulina*, *Enteleles* cf. *hemiplicatus*, 1 *Productus* cf. *inflatus*, 1 *P.* cf. *pustulatus*, 1 *P.* cf. *longus*, 1 *P.* cf. *irginæ*, *Marginifera* cf. *wabashensis*, 1, 2 *Spirifer* cf. *marcoui*, *Seminula mexicana*, 1 *Camarophoria* cf. *mutabilis*, 1, 2 *C.* cf. *crumena*, 2 *Dielasma* cf. *truncatum*, 1 *Omphalotrochus obtusispira*.

Regarding these formations and their correlation, Girty writes :—

“The Carboniferous faunas of the Trans-Pecos region, especially the upper ones, differ widely from those of the Central and Eastern States. The fauna of the Hueco formation, however, is found with some modifications over most of the area west of the Rocky Mountains; but the remarkable group of fossils occurring in the Capitan limestone is only known in the Guadalupe Mountains. The fauna of the Capitan limestone differs to a marked degree from that of the Hueco formation, and was assigned to the Permian epoch both by Shumard, its original discoverer, and by Girty. The fact that the faunas of the Hueco formation in some respects strikingly resemble those of the *Spirifer marcoui* zone, the *Omphalotrochus whitneyi* zone, the *Productus cora* zone and the *Schwagerina* zone of the Carboniferous section of eastern Russia, which immediately underlie the typical Permian, seems to support the views of these authors. On the other hand, there are some matters of difference between the Russian faunas and those of the Hueco formation, part of which are points of agreement with the Capitan fauna. Thus, the Russian faunas, even the highest (that of the *Schwagerina* zone), seem, aside from containing aspects not found in either, to combine features of both the Hueconian and the Capitan faunas, features, moreover, which these formations do not possess in common.

“The American beds can hardly be looked on as being a mere expansion of the Russian series, since the Hueco, Delaware Mountain and Capitan formations combined have a thickness much exceeding 5000 feet, while the four zones recognized by Tschernyschew are considerably less than 1000 feet thick. In view, therefore, of the preponderating resemblance shown in the Hueco faunas and the differences in that of the Capitan limestone, the latter is retained under the title of Permian, and with it, provisionally, the Delaware Mountain formation” (2, pp. 42-43).

The latest paper by this same author makes the following important statement regarding the Permian question, and gives his views concerning the equivalence of the formations in the various American regions :—

“The opinion has been expressed that the Pennsylvanian faunas of eastern and western United States may belong in different provinces, and that they are probably to some extent equivalent. The belief is tentatively held that the highest of our Western horizons are considerably younger than the highest known invertebrate horizons of the East, those of the Kansas section, for instance, which are characteristic of the so-called Permian of the Mississippi Valley. In spite of the able pen

which have traversed this subject, the correlation of these beds is still one of the unsettled problems of the American Carboniferous. If the Capitan fauna is Permian, then certainly that of Kansas is not, for 2 Carboniferous faunas could scarcely have less in common. While it is possible that the so-called Kansas Permian is a provincial phase of the Guadalupian, this is yet to be demonstrated, and it is questionable whether for 2 faunas so essentially unlike, even if proved to have been contemporaneous, the same name could with propriety be used. On the assumption that the Kansas beds are Permian, so closely are they connected, faunally and stratigraphically, with those below, the term Permian must be reduced to denominate a difference not much greater than that between the Burlington and Keokuk, or else most of the Kansas section must be placed in the Permian, a disposition against which there is much evidence. It seems probable that the Kansas Permian represents a faunal development in a distinct province from that of the West, the Western faunas being co-provincial with the typical Permian sea. The equivalence of the Kansas Permian is not to be determined upon the basis of a community of a few slightly differentiated long-lived types, but must be worked out by a consideration of the fauna as a whole and the facies which it receives from the presence of equivalent but probably not equal species.

"The Guadalupian faunas are not only widely different from those of Pennsylvanian age in the Mississippi Valley, but they appear to have a distinctly younger facies, biologically considered. So far as the significance of the somewhat hastily reviewed evidence has been grasped, it seems to assign the Kansas faunas to about the horizon of the Hueco formation, placing the entire Guadalupian series, or at all events the Capitan, as a younger evolution, whether the 2 faunas were developed in distinct provinces or in the same" (3, pp. 25-26).

The late Paleozoic formations have great development in Alaska, but as yet the faunas have only been partially studied. Schuchert's (Prof. Paper 41, U. S. Geol. Survey, 1905, pp. 42-45) conclusions regarding these fossils are as follows:—

"In looking over the collection listed in the large table not submitted in this report, the first impression made is its strangeness when compared with other American late Paleozoic faunas, excepting that of northern California as yet unpublished. Nearly every species is new, certainly new for North America so far as the published record goes. The developmental aspect is clearly late Paleozoic, and yet there is not present a single diagnostic upper Carboniferous or Permian species of the Mississippi Valley. Further, we miss of the brachiopods of the last-named basin the ever-present

Rhipidomella, *Enteleles*, *Derbya*, *Meekella*, *Seminula*, and *Hustedia*. On the other hand, this arctic fauna predominates in *Productus* and *Spirifer*. Of the former genus the species are nearly all strangers to American paleontologists, since the bilobed or deeply sinused and the abundantly spinose forms are the common ones. The *Spirifers* also are strange in that hardly any have the plications strongly bundled as in *S. cameratus*, while such little known groups as that represented by *S. arcticus* and *S. supramosquensis* (also recalling *S. neglectus* of the Lower Carboniferous) predominate.

"Ten or more species of Bryozoa are present, of *Fenestella*, *Pinnatopora*, *Goniocladia*, and *Rhombopora*. None, however, can be specifically identified and those of the genus *Rhombopora* are of a type—stout branches from $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter—unknown in the Mississippi basin. This is also true of *Goniocladia*. Pelecypoda are all small and rare (5 species), and the Gasteropoda (3 species, 4 specimens) almost absent. Not a trace of a cephalopod is present, and this is all the more strange since the Indian Permian has 14 forms of nautiloids and 7 of ammonoids. Nor is there a trace of a trilobite, while the corals are represented by one or two species of cyathophylloids.

"The work of the United States Geological Survey in California and Alaska is establishing two facts of great value in general geology, namely, that on the west coast of North America there is (1) a great thickness and grand sequence of Carboniferous and Permian strata [between 6000–7000 feet of Permian in Copper River region of Alaska]; (2) that these have faunæ of the Pacific type and not of that of the Mississippi basin" (p. 44).

CONCLUSIONS.

As the great Russian geologist has stated in his introduction that he will be the first to greet friendly criticism "with pleasure," the present reviewer takes the opportunity of concluding this long review with the following friendly remarks:—

1. The foregoing review of the recent work of four excellent investigators in the correlation of Carboniferous and Permian strata and faunas shows clearly that a final interpretation of the sequence of events closing the Paleozoic is still far from attainment. Further, that while harmony exists regarding the basal zone of the Carboniferous (Upper Carboniferous of most writers), there is as yet no agreement as to the upper limits of this system of rocks and hardly any concerning the delimitation and sequence of the Permian. As has been seen, there is little or no difference of opinion in regard to the sequence of

events in a given area; but when it comes to correlating these local sections with those of other continents, there is great diversity of interpretation relative to the values to be placed on the varying faunas. This lack of harmony is primarily due to the absence of a continuous faunal sequence in any one region. Further, some paleontologists draw their species finely, others broadly; and as all the Carboniferous faunas have a general facies in common, far more decided than that of any other Paleozoic system, and finally, as many of the groups of brachiopods, the prevailing fossils of the Carboniferous and Permian, have lost their power for rapid or marked progressive evolution, with a decided tendency toward degeneracy, the possibility for wide differences of opinion regarding sequential change in faunas is apparent. Then, too, the centers of radial dispersion of the faunas have not yet been determined, so that no reliable means exists for ascertaining the differences in age of the same or closely related faunas between widely separated areas. However, as the Carboniferous is nearly everywhere characterized by an abundance of fossils, and as there is already an extensive literature on the subject, a final interpretation of the sequence of events, that will carry conviction to all workers, may very soon be looked for.

2. To the present writer, it is clear that the Permian fauna of the Urals and Timan is not the normal marine one perpetuating the Paleozoic sequence in the Mesozoic. (The same is true for Germany and England.) Of brachiopods are missing here the plicate and other types of terebratuloids other than *Dielasma* and everything from which the rhynchonelloids can be developed, spire-bearing forms and the strophomenoids of the type of the Lyttoniidae. The same is largely true for the other classes of organisms; in fact, one can better trace the Triassic faunas of the Alps through the Ural and Timan faunas of a lower horizon, *i. e.*, those of the Schwagerina zone. These facts are admitted by Tschernyschew, but it seems to the reviewer that he fails to give proper weight to the probability which one almost wishes to state with certainty, that somewhere the Schwagerina fauna or one closely related to it continued to maintain itself, and, further, that in some region far away from the Urals and Timan it will necessarily hold a higher stratigraphic position, although somewhat changed in faunal facies. This center of dispersion was seemingly the Mediterranean region; in fact, it is the belief of the reviewer, derived from a knowledge of the Permian of Sicily and Austria, that this great body of water, Thetys, was the home of the normal marine Carboniferous and Permian faunas of Europe and Asia. From Thetys, the faunas spread to the north into the epicontinental seas of Germany and European Russia, but in

these waters, during Permian time, conditions were not favorable for the continuance of a normal marine life, and finally these faunas die out here in the gypsum and copper-depositing seas. To the south in a mediterranean, the faunas maintain themselves in a healthy and prolific condition, spread eastward across Asia and probably westward as far as El Paso, Texas; while other migrations seemingly of a somewhat different facies, but having more of the Himalayan-Arctic impress, are met with along the Pacific coasts from California far north into Arctic western America. Under these circumstances, it should not be expected that the Schwagerina zone of the Urals will hold a horizon in India or America similar to that in the Urals and Timan.

3. The question—Is there a Permian system or only a Permian formation?—is far from answered. In the area typical for the rocks under consideration, the Perm Province in the Urals of Russia, the normal marine Carboniferous fauna passes into Permian deposits of an abnormal marine character and finally into red gypsiferous shales devoid of life. Under such an environment, an abundance of life, with progressive or normal evolution, is excluded and, as a rule, there remains only the widely distributed species, and too often merely characterless forms are present, which do not permit safe deductions to be made in determining the chronology of a Permian system. At present, there is no acceptable sequence of faunal events for intercontinental correlation in the typical area and as far as can now be seen there will certainly be none for the closing events. The German Permian faunas are better known, but as they are clearly only a part of a great sequence and as the lower and upper stratigraphic members of this region are either devoid of fossils or have no normal marine succession, positive proof as to the entire sequence of events in a Permian system can not be looked for in this country. In England, the conditions seem to be those of Germany. In the Salt Range of India, either toward the close of the Carboniferous or early in the Permian, a great glacial period was in progress, so that in this region there are no normal marine beds in the lower part of the section; hence, no possible biological base for the system is yet apparent. On the other hand, in the central Himalayas above a vast series of Lower Carboniferous strata (5,000 feet thick), there is a marked unconformity above which occurs Permian sediments, parts of which are positively correlated with the uppermost group—the Chidern—of the Salt Range. These strata then continue without apparent break in sedimentation into the *Ceratites* beds of the Triassic. This time hiatus—a land interval with erosion—is probably equivalent not only to all the Upper Carboniferous but possibly also to

a part of the *Productus*-limestone of India. This great unconformity will be of much value in the final interpretation as to the proper position in the time scale of the entire *Productus*-limestone and as well the date for the period of glaciation in the late Paleozoic of India.

In America, however, in southwestern Texas, there is an unbroken section of more than 9000 feet in thickness, having more than 4000 feet of limestone, with normal marine faunas at various levels. As has been evident from the statements of Girty, this section has Carboniferous faunas of the Euro-Asiatic type, which are directly comparable with the *Spirifer marcoui*, *Omphalotrochus whitneyi*, *Productus cora*, and the *Schwagerina* zones of Tschernyschew. These Carboniferous faunas are in the lower portion of the section, above which, in the Capitan limestone, are faunas comparable with those of the *Productus*-limestone of India (*i.e.* faunas having *Goniocladia*, *Richthofenia*, *Lyttonia* (= *Leptodus*) etc.),—faunas that for some years have been regarded by several of the leading stratigraphers as the normal marine record toward the close of the Paleozoic. It is to be hoped that the U. S. Geological Survey will soon enable Dr. Girty to complete his studies, both stratigraphic and faunal, regarding this, the most complete Carboniferous and Permian section known to stratigraphers.

4. The question as to what name the closing Paleozoic system shall bear can not as yet be answered. If the rocks of the Permian area of Russia should fall into the Carboniferous, the way will open for another term for the closing system. From the accumulated evidence, there appears to be need of such a system in the classification. However, should the Permian rocks of Russia form but a member of a "Permian system" (the trend of evidence is in this direction), there would then be a choice between the Permian of Russia, the *Dyas* of Geinitz, the *Guadalupian* of Girty (*Oklahomian* of Keyes is rather a formation than a time term), and possibly other terms.

As workers in many countries are coming more and more to adopt a classification expressing the local physical and faunal events, the time does not seem far away when the matter of an all-embracing or world chronogenesis will have to be taken up by the International Geological Congress. Whatever the criterion for such a terminology, indicating the grander events in the world's chronogenesis, may be, it certainly can not be the one now in use, *i.e.*, the local events of a given area, the first to propose a term or terms however badly understood. A new set of system terms for general application suggested by an organization like the International Geological Congress would at once bring into use, for local areas, such despised terms as *Taconic* and *Cambrian*, and thus furnish relief from

the ever-recurring disputes concerning Lower Silurian, Cambrian, Cambro-Silurian, Ordovician, or Champlain.

5. Tschernyschew lays great stress upon the occurrence of a form of the brachiopod family Lyttoniidae in the Schwagerina horizon of the Urals. Certainly it has great faunal value, but the acumen of Tschernyschew also led him to note the fact that it is not of the Indian genus *Lyttonia* (= *Leptodus*). To it he gave the generic name *Keyserlingina*, and the few involutions of the brachia indicate that it has not yet progressed to that degree of specialization shown in the brachia of the Indian genus *Lyttonia*. In other words, *Keyserlingina* holds a lower stratigraphic horizon than *Lyttonia*. In the Austrian Alps, another primitive form of the Lyttoniidae is found, but here the brachial folds are not laterally directed as in the other forms, but anteriorly. Hence, it is not in the direct line of evolution with the Indian genus, which has also been discovered in Nevada and at El Paso, Texas (Dr. Girty states that he also has it from the Robinson beds of California). The reviewer therefore believes that while *Keyserlingina* unmistakably indicates that the Schwagerina fauna is of the Asiatic type, it is less highly specialized than *Lyttonia*, and consequently holds a lower geological horizon.

6. In regard to Tschernyschew's conclusion that the Russian Permian brachiopods show "atavistic trends," the writer does not think it is borne out by the facts. A list of the species is given on page 31. All of the forms occur below either in the Artinsk or the Upper Carboniferous. In fact all are persisting or long-lived species and are therefore not atavistic in any phylogenetic sense. The brachiopod fauna of the typical Permian, however, may be said to be atavistic in aspect because all of the progressive forms of the Artinsk have failed to continue into this formation.

7. The reviewer, from his knowledge of the late Paleozoic brachiopods, is confident that this class of fossils can be relied on for detailed correlation of stratigraphic horizons over widely separated regions, and further on account of their persistence and wide distribution they are among the best evidence for facial affinity. The Carboniferous and Permian brachiopods are given too great specific latitude by many paleontologists, so that it is common in the literature of the subject to note that many species are found on more than one continent. *Productus semireticulatus* is believed to occur throughout all Carboniferous time and is common to the world. Such a condition permits of no exact correlation.

8. The writer can not see that the evidence as presented by Tschernyschew breaks down the laboriously attained conclusions of Waagen, Noetling, and Diener, that the Productus-

limestone (certainly the upper member or Chideru formation) is not younger than any part of the Permian of the Urals or Timan. The *Schwagerina* brachiopod fauna of the Urals seemingly arrives later in India, and during this interval has greatly changed. It is this altered character that dominates the faunas of the Middle and Upper *Productus*-limestone. This alteration is seen in the progressive development and specialization, not only of the *Lyttoniidae*, but as well of the *Richtofeniidae* and the *terebratuloids*.

9. In regard to the contention of the Indian geologists and Noetling that the Indian *Productus*-limestone passes without stratigraphic break into the Triassic, some weight should be given to Tschernyschew's faunal argument. In Kentucky, the Devonian overlaps the Ordovician, and in Alabama, the Carboniferous the Ordovician, without visible stratigraphic break; if it were not for the fossils entombed, the maps of these regions would have shown but one formation. From the fact that not a single species is known to pass from the *Productus*-limestone into the higher *Ceratites*-bearing beds of India, one would naturally look here for a late Permian or early Triassic land interval, followed by an overlap of Triassic age. However, the fact that no unconformity nor break in sedimentation has been discovered either in the Salt Range or in the central Himalayas, and further that in the latter area there is a great unconformity between the Permian and the Lower Carboniferous (which has a thickness of 5,000 feet), are evidence rather against the supposition that the Triassic overlaps the Permian. The absence of any Permian species in these lower *Ceratites* beds and the rapid lithologic change between the Permian and Triassic may here be necessary conditions resulting from the great "revolution" taking place in both hemispheres between the Paleozoic and Mesozoic. It is not only the colder glacial land waters poured into the oceans of Permian time at many widely separated areas that have changed the long previous equable habitat of marine faunas, but extermination came as well through the greatly reduced continental shelves, due to the higher altitudes of the continents in the Northern Hemisphere during late Permian time. (This is especially true for North America.) In other words, the stable conditions of the *Productus*-limestone were interrupted by the Permian revolution going on elsewhere, killing the entire fauna of this immediate region. That this revolution did affect the Salt Range seas is seen by the change in sedimentation, and with it came extermination of its life followed very shortly by an immigration of a new but not greatly changed ammonite fauna.