The Russian Carboniferous and Permian compared with those of India and America : a review and discussion / by Charles Schuchert.

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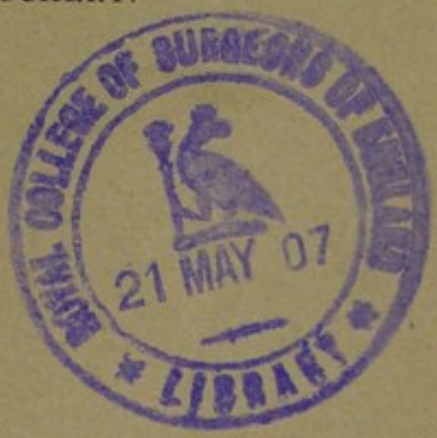
The RUSSIAN CARBONIFEROUS and PERMIAN COMPARED with those of INDIA and AMERICA. A REVIEW and DISCUSSION.

By Charles Schuchert.



ART. VII.—*The Russian Carboniferous and Permian compared with those of India and America. A Review and Discussion;* by CHARLES SCHUCHERT. (With Plate I.)

CONTENTS:

PART I. THE WORK OF TSCHERNYSCHEW.

Die Obercarbonischen Brachiopoden des Ural und des Timan. Von Th. Tschernyschew. Mem. du Comité Géol., vol. xvi, 1902 [1903], pp. i–viii, 1–749, and 63 plates.

THIS large and exceedingly valuable monograph describes the brachiopods collected by the author and others during eight years in the Ural and two years in the Timan districts of European Russia. The great number of 213 species are described, and two new genera—*Keyserlingina* and *Spiriferella*.

In the present review of this monograph, the author's general conclusions regarding the occurrence of these forms in the various horizons and their significance in correlation only will be taken into account. In fact, Tschernyschew's correlations are of the first importance, and will be fully presented here.

In the introduction the author states: —

"It is my opinion that the exceptional richness of the fauna of the Upper Paleozoic sediments of Russia and the positive succession of the various horizons give us the right to regard eastern and northern [European] Russia as the starting point for the correlation of similar deposits in other countries. . . . Not infrequently my views differ from those of my colleagues in western Europe and America, and in recording these conclusions in the final chapter of my work my chief object has been to present the views of one geologist who in the course of many years has studied the upper Paleozoic deposits in the vast territory of Russia. It is very probable that some of my freely-stated assertions will be strongly criticized by geologists both at home and in foreign countries, and I shall be the first to greet such criticisms with pleasure" (pp. vi, vii).

Of the 213 species of brachiopods known in the "Upper Carboniferous" of Russia, 61 pass into the Artinsk zone and but 10 into the typical Permian. The latter are *Dielasma elongatum*, *Rhynchopora nikitini*, *R. variabilis*, *Camarophoria crumena*, *C. superstes*, *C. globulina*, *Athyris pectinifera*, *A. roissyi*, *Spiriferina cristata*, and *Productus* aff. *leplayi*.

These make it clear that this is not the normal marine fauna that continues the Paleozoic sequence into the Mesozoic. This point, however, will be discussed on a later page (see "Conclusions," paragraph 2).

In regard to the Russian faunas the author states :—

"I wish to call attention to the decided differences which make their appearance in the fauna of the Omphalotrochus horizon when contrasted with the type of that of Miatschkowo [near Moscow; also see the following table for stratigraphic position], and on the other hand the great resemblance of the brachiopod fauna of the Schwagerina zone to that of the higher lying Permo-Carbon (the Artinsk deposits CPg and the Limestone-dolomite CPc). In the lower Permian fauna of Russia we have already noted a decided reduction in Brachipoda, if not in quantity, at least in variety of species; and in the still higher horizons of the Russian Permian, the total number of Brachiopoda is not more than 40 species [this number has reference to all areas correlated with the typical Perm area]. Entire groups of forms . . . that give a decided aspect to the fauna of the Upper Carboniferous Artinsk, and the Limestone-dolomite beds, are completely unknown in the Permian sediments of Russia and west Europe. Some of these groups therefore attract our attention because they are foreign to the Permian deposits, yet in the Mesozoic (Trias and Jura) they attain an extended development. On the other hand, others belong to such original types as the Lyttoniidæ, *Tegulifera*, and *Orthotichia*, forms that give a decided character to the upper Paleozoic, and, so far as our knowledge goes, completely disappear with the Permian epoch [of western Europe]. From a biological standpoint there can be no doubt that our Upper Carboniferous brachiopod fauna has the facies of a younger type than the Permian, and that in its entirety it has a more decided Mesozoic impress than that of the [Russian] Permian following, which when compared with the other shows atavistic trends [see note 6]. As it is my opinion that this atavism finds its proper explanation in the physico-geographic conditions of the Permian sea, I hold that it is not superfluous to direct special attention to this fact, and thereby to moderate the tendency of some geologists, who in their determination of the age of this or that fauna depend mainly upon the biological peculiarities and not infrequently leave out of consideration the possible explanation that the biological differences between two synchronous or at least closely adjoining faunas are partially due to facies and chorological causes" (pp. 663–4).

"Although the data presented regarding the distribution of Upper Carboniferous deposits in the region of European

Russia show that we can not fix with certainty the exact shore-lines of the sea of this epoch, still from the general distribution and the nature of the sediments of this time, when compared with those of the Middle Carboniferous epoch, we may conclude that there was a retreat of the sea in the west. In the north the Upper Carboniferous sea had great extension and communicated freely with the far-reaching Polar sea. In the east it was limited by the Ural barrier, behind which in Siberia lay a series of more or less extensive basins of brackish or fresh water" (p. 679).

For the sake of completeness, the reviewer will here introduce a somewhat detailed generalized section of the Permian and Carboniferous of Russia, compiled from various recent sources:*

Brackish ?Permian or ?Triassic, Tartarian (PT).

Red grits, argillaceous sands, and intercalations of clay and marl of the same color; rarely green or bright blue.

Red colored marls and variegated clays, with intercalations of grayish grits and sands of the same tints.

These two groups have brackish-water genera, as *Unio*, *Anthracosia*, *Najadites*, and *Palæomutela*.

Permian (P) of Samara and Oufa (the Permian sensu-stricto of Murchison).

Brown grits, marls, and limestone.

Has some pelecypods, as *Allorisma elegans*, etc.

Gray slaty limestones, with intercalated marls and friable grits.

Has *Murchisonia subangulata*, *Turbonilla altenburgensis*, *Macrodon kingianum*, *Osteodesma kutorgana*, *Modiolopsis pallasi*, *Leda speluncaria*, etc. Of Crustacea, *Bairdia*, *Estheria*. *Lingula orientalis*. Of fishes, *Palæoniscus*, *Acrolepis*.

Grits and gray limestone, more or less copper-bearing.

Rich in brachiopods: *Spirifer regulatus*, *Spiriferina cristata*, *Athyris pectinifera*, *Dielasma elongata*, *Productus cancrini*, *P. hemisphæricus*, *Strophalosia horescens*. Some bivalves and corals.

Red argillaceous grits, with intercalations of clay and gray, brown, and reddish marls.

Fossiliferous only in the higher beds: *Productus cancrini*, *Athyris pectinifera*, *Dielasma elongata*, *Allorisma elegans*, *Macrodon kingianum*, etc.

*The Permian and Moscowian section is taken from Nikitin—"De Moscou à Oufa (via Miatschkowo, Riazan, Penza, Syzran, Samara)," Guide des Excursions, VII, Congrès Géol. Internat., 1897, Pt. II; the Uralian, from Tschernyschew's great brachiopod work here reviewed; the Viséian and Artinsk, from Tschernyschew, Mém. du Comité Géol., III, No. 4, 1889.

Argillaceous limestones and marls of variegated tints. No fossils.

Gypsiferous group of limestone, gypsum, and clay. No fossils.

Permo-Carboniferous, or Artinskian (Lower Permian of many authors).

Horizon CPc, or dolomitic-limestone zone. A gray or yellowish gray cavernous limestone passing often into dolomite, brecciated or conglomeratic in composition, with intercalated beds of oolite and occasionally shale.

Has a fauna smaller than, and almost identical with, that of horizon CPg. *Cladodus*, *Dielasma hastata*, *D. elongata*, *Spiriferina cristata*, *Rhynchopora nikitini*, *Chonetes variolaris*, *C. verneuiliana*, *Productus purdoni*, *P. cora*, *Marginifera typica*, *Fusulina verneuili*, and *Bradyina nautiliformis*.

Horizon CPg, or Artinskian *sensu stricto*. "Peppery" sandstone, with intercalations of shales. In places conglomerates, limestone, shales, and slates.

Has *Phillipsia gruenewaldti*, *Pronorites præpermicus*, *Agathiceras uralicum*, *Medlicottia artiensia*, *Gastrioceras*, *Popanoceras*, *Parapronerites*. Of Upper Carboniferous brachiopods, 61 species pass into this zone. Among the more prominent fossils of the zone are the following: *Dielasma elongata*, *Spirifer fasciger*, *S. alatus*, *Spiriferina cristata*, *Spiriferella saranæ*, *Rhynchopora nikitini*, *Camarophoria plicata*, *Streptorhynchus pelargonatus*, *Productus spiralis*, *P. lineatus*, *Marginifera typica*, *Fusulina verneuili*.

Upper Carboniferous, or Uralian.

Schwagerina zone (C^3_3), about 60 meters thick in Timan.

Abounds in *Schwagerina princeps*. Other Foraminifera are *Fusulina verneuili*, *F. longissima*. Of corals, there are many species, mostly of the compound type. Of Bryozoa, the most striking is *Archimedes*. This is the horizon *par excellence* for brachiopods, Tschernyschew recording 194 forms. *Dielasma* in greatest abundance, with 13 species; *Hemiptychina* 4, none below; *Notothyris* 3; *Aulacothyris* 2; *Keyserlingina* 2, none below; *Terebratuloidea* 2, none below; *Pugnax* 8; *Camarophoria* 14; *Spiriferina* 8; *Spiriferella* 4; *Spirifer* 21; *Martiniopsis* 7, none below; *Martinia* 13; *Reticularia* 4; *Meekella* 2; *Orthotichia* 1, none below; *Chonetes* 11; *Aulosteges* 1; *Productus* 40; *Proboscidella* 3 (these are not of the type of the Lower Carboniferous, having had another

origin); *Marginifera* 8. Pelecypods also common and of the ordinary Upper Carboniferous types. Of cephalopods, *Agathiceras uralicum*, *Pronorites cyclolobus uralensis*, *P. postcarbonarius*. Trilobites, *Griffithides roemeri* and *G. gruenewaldti*.

Productus cora zone ($C\frac{2}{3}$), about 70 meters thick in Timan and 100 in southern Ural. The most abundant fossil is *P. cora*. Other brachiopods are *Dielasma*, 4 species (*bovidens*); *Camarophoria* 4; *Spiriferina* 2; *Spiriferella saranæ*, *Spirifer cameratus*, *S. condor*, *S. fasciger*, *S. marcoui* (goes no higher), *Derbyia regularis*, *D. crassa*, *Meekella striaticostata* and 3 other species; *Chonetes mesoloba*, *C. granulifera*, *C. flemingi*, *C. variolata*, *Aulosteges*, *Productus boliviensis* and 21 other forms, *Marginifera uralica* and 4 other forms. Corals are rare, especially the compound forms so common both above and below. *Archimedes* rare. Large *Fusulina verneuili*. *Griffithides scitula*.

Omphalotrochus zone ($C\frac{1}{3}b$). This zone and the one below have a united thickness of about 70 meters. Most abundant fossil *Omphalotrochus whitneyi*. Of brachiopods there are *Dielasma itaitubense*, *Camarophoria* 3, *Spirifer marcoui*, *Derbya crassa*, *D. regularis*, *Meekella striaticostata*, *Aulosteges*, *Productus nebrascensis*, *P. cora*, *P.* 10 species, *Marginifera uralica*. Corals very abundant; this zone in the Urals is 12 meters thick.

Spirifer marcoui zone ($C\frac{1}{3}a$).

Has an abundance of *S. marcoui* and corals.

Middle Carboniferous, or Moscowian (C_2), about Miatschkowo.

1. Greenish white fragmental limestone, ·3 meter thick.
2. Greenish compact argillaceous limestone, ·7 meter thick.
3. Yellow dolomitic limestone, $2\frac{1}{2}$ to 3 meters thick.
   Abounds in fish teeth and plates of *Cladodus*, *Dactylodus*, *Deltodus*, *Ostinaspis*, *Pœcilodus*, *Polyrhizodus*, *Psephodus*, *Psammodus*, and *Solenodus*. Also *Productus semireticulatus*.
4. Grayish compact limestone, $1\frac{1}{2}$ to 2 meters thick.
5. White granular soft flaggy limestone, 2 to 3 meters thick.
   Has a normal marine fauna. Those preceded by 1 are the characteristic species. Has many of the fishes found in 3, and *Cymatodus*, *Helodus*, *Orodus*, *Petalodus*, and *Tomodus*. Also *Nautilus mosquensis*, *Euomphalus pentangulatus*, *E. marginatus*, *Macrocheilus ampullaceous*, *Allorisma regulare*, *Conocardium uralicum*, *Productus cora* (*riparius*), *P. lineatus*, 1 *P. semireticulatus*,

P. longispinus, *P. punctatus*, 1 *Enteletes lamarcki*, *Meekella eximia*, 1 *Spirifer mosquensis*, 1 *S. strangwaaysi*, *S. fasciger*, and 1 *Seminula ambigua*. In the clay bands this is also the horizon for crinoids *Cromyocrinus*, *Hydriocrinus*, *Phialocrinus*, *Poteriocrinus*, *Stemmatocrinus*, etc. Also *Archiocidaris rossica*, *Lepidesthes*, and *Calliastes*. Several species each of *Fenestella* and *Polypora*. Of corals, *Bothrophyllum conicum*, *Petalaxis* and 1 *Chætetes radians*. Also *Fusulina cylindrica*, but not readily seen.

6. Fusulina limestone made up of Foraminifera and crinoidal matter, 1 meter thick.
   Has some of the fishes also found above, *Nautilus* 6 species, *Productus semireticulatus*, *P. punctatus*, *Meekella eximia*, *Enteletes lamarcki*, *Spirifer mosquensis*, *Archiocidaris rossica*, *Chætetes radians*, *Syringopora parallela*, *Bothrophyllum conicum*, *Axophyllum rossophyllum*, *Fusulina cylindrica*, *Bradyina*, *Endothyra*, *Fusulinella*, *Cribrostomum*, and *Tetrataxis*.
7. Yellowish white hard compact limestone, 1½ to 2 meters thick.
8. Dirty white limestone.

Lower (?) Carboniferous, or Viséian.

Upper limestone (C_1^2).
   Has *Allorisma regularis*, *Rhynchonella pleurodon*, *Seminula ambigua*, *S. subtilita*, *Schizophoria resupinata*, *Productus longispinus*, *P. corrugatus*, *P. pustulosus*, *Fusulina verneuili*, *Fusulinella sphæroidea*, etc.

Lower limestone (C_1^1).
   Has an abundance of corals, *Syringopora gracilis*, *Lithostrotion affine*, *L. cæspitosum*, *L. irregulare*, and brachiopods, *Productus giganteus* and *Chonetes papilionacea*. Also *P. striatus*, *Athyris squamigera*, *A. expansa*, *Martinia glabra*, *Phymatifer pugilis*, *Phanerotinus serpula*, *Phillipsia globiceps*, etc.

Devonian.

Correlations with India.

Tschernyschew regards it as "highly desirable to discuss in detail the section of the Salt Range, which, as far as the sequence of the horizons and their paleontological characteristics are concerned, is described more completely than is any other region of Asia. This area is at present not only the starting-point for the correlation of other Asiatic regions, but for the Austrian Paleozoic as well; hence I hold that my view regarding this profile will not be unacceptable" (p. 715).

Of the many Indian species of Brachiopoda, the author finds that 31 are also known in the Ural-Timan region. To these he has added 13 other species not common to both areas, but which clearly have related forms. He then discusses the distribution of these various species in the beds of India and the Ural-Timan region, and concludes:—

"Of great significance is the occurrence of the family Lyttoniidæ in the Schwagerina horizon of the Ural and the Virgal beds of India. This occurrence is of great moment and significance in the history of the upper Paleozoic of Russia" (see "Conclusion," paragraph 5).

"Through a comparison of the brachiopod fauna of the Upper Carboniferous deposits of the Ural and Timan with those of the various subdivisions of the Productus-limestone of the Salt Range, we clearly see that the lower Productus-limestone, or the Amb beds [see tables on pp. 32, 37], is more properly correlated with the Ural-Timan horizon having *Spirifer marcoui* and *Omphalotrochus whitneyi*, and that in our Schwagerina horizon we more naturally may discern the greater part of the Middle Productus-limestone, while the homotaxial sediments of the Cora horizon we have to seek in the upper layers of the Amb beds and probably also in the lower horizons of the Middle Productus-limestone, or in the Virgal group (according to Noetling's nomenclature). In this parallelism the Kalabagh beds [upper division of the Middle Productus-limestone] and the Upper Productus-limestone (in any event, the major part) well represent the Artinsk deposits and their equivalents of the Ural."

"This result is in the main at variance with the prevailing views as to the age of the various subdivisions of the Productus-limestone of the Salt Range, and approaches decidedly the original conclusion that the age of these beds is Carboniferous. I foresee that against my deductions the objection will be raised that they are based on a comparison of the brachiopods alone, but I can also defend them through other classes of the animal world. Moreover, I wish to say a few words in regard to the Cephalopoda, especially the ammonites." He then discusses the ammonites of Russia and Sicily, as described by Karpinsky and Gemmellaro, and lays particular stress upon the conclusion of the former, which he quotes as follows: "That the Sicilian fauna is somewhat earlier in origin than that of the Urals, although they, as I will again assert, approach closely the Artinsk. On the other hand, it is possible that the differences mentioned are due to chorological causes. The complicated Arcestidæ, for instance, can only belong to the southern regions" (pp. 719–20).

Because of the wide distribution of the remarkable fish *Helicoprion* in North America,* Japan, India, and Australia, and of the fact that in the Ural all the specimens of this genus are from the Artinsk horizon, Tschernyschew holds that these data should be given great weight, since so peculiarly constructed an animal "must have had a very restricted duration" (p. 722).

"According to my judgment all that has been said is strictly against the conclusion of Waagen and his adherents, who see in the Productus-limestone the entire Permian series of Russia. In the general chronological scheme the Productus-limestone has to take a deeper position than that assigned to it by Waagen, Noetling, and others" (p. 725).

Regarding Noetling's statement that the Productus-limestone passes without break into the Ceratite-bearing beds of the Triassic, Tschernyschew admits it to be "a very serious argument in favor of the intimate stratigraphic connection between the Trias and the Permian in the Salt Range, and the entire question relative to the discordance or transgressive nature of the beds appears to him [Noetling] impossible in such close association." Tschernyschew answers that the total dissimilarities in the faunas of the Productus-limestone and the Ceratite beds of the Triassic, which are separated by only a few meters (in fact not a single species passing from one into the other, according to Waagen), cannot be accounted for, as Noetling thinks, by the changeable nature of the sediments at this level. "Such a sharp paleontological boundary is, rather, testimony for a transgressive superposition of the Trias on the Paleozoic of the Salt Range." He then states that numerous Paleozoic and Mesozoic examples of supposed continuity, with very similar lithologic deposits, were later shown by the Russian geologists to be discontinuous and transgressive, with great chronologic differences. "With this I shall allow the matter to rest, adding the further statement that I believe the evidence cited by Noetling not to have the strength of sound proof in favor of a gradual replacement of the Permian sea in the Salt Range by the Trias, the sharp paleontologic boundary between these deposits indicating, rather, a transgressive superposition of the Scythian stage upon the Productus-limestone" (pp. 726–27).

As the Otoceras beds of the Himalaya, supposed to be transitional between the Productus-limestone and the Ceratites beds of the Salt Range, enter largely into the question whether the latter are not transgressive upon the former, Tschernyschew discusses the matter as follows:—

"What relation the zone with *Otoceras woodwardi* and *Ophioceras tibeticum* in the Himalaya bears to the section of

* This genus is unknown in North America, and the author probably has reference to the related type *Campyloprion lecontei* occurring in Nevada. See Eastman, Amer. Nat., June, 1905, pp. 405–409.

the Salt Range is a problem that still needs a final solution. Paralleling it with the upper horizon of the Upper Productus-limestone, the correlation is primarily based on the identity of *Medlicottia wynnei* Waag. of the Salt Range with *M. dalailamæ* Diener, which Krafft (A. v. Krafft, Ueber d. perm. Alter d. Otoceras-stufe des Himalaya. Centralbl. f. Min., Geol. u. Pal., 1901, pp. 275–279) says represent but one species. However, as Waagen's original specimen is, according to Krafft, very badly preserved, this stated identity requires better material for its proof. It is all the more necessary to be careful, because in the Artinsk beds of Russia were found Medlicottias that much remind one of *M. wynnei* Waagen. In any event, before the correlations of Noetling (Neues Jahrb., Beil.—Bd. XIV, table facing p. 468) can be accepted it is necessary to prove an uninterrupted paleontological connection from the zone with *Cyclolobus oldhami* and *Hemiaspis carbonarius* to the beds with *Otoceras woodwardi*" (p. 727. See Noetling's recent work on the Otoceras beds of the Himalaya here reviewed).

Tschernyschew states that until the entire Permo-Carboniferous fauna of Russia is worked out, no positive correlation can be made, but for the present the equivalent as presented in the following table is the most probable (p. 728):—

	Salt Range		Ural and Timan
Upper Productus-limestone	Chideru beds Jabi beds Khund-Ghat beds	Chideru of Noetling	Lower Permian of European Russia Limestone-dolomite horizon CPc and Artinsk beds CPg
Middle Productus-limestone	Kalabagh beds Virgal beds Katta beds	Virgal of Noetling	Schwagerina zone, 50 to 60 meters
Lower Productus-limestone	Amb beds of Waagen and Noetling		Cora zone, 70 to 100 meters Omphalotrochus zone Spirifer marcoui zone 60 to 70 meters
	Warcha beds (Speckled sand and Lavender clay) Dandote beds Talchir bed (Bowlder clay)	Pendschat of Noetling	Middle Carbon with *Spirifer mosquensis* of the east slope of Urals Conglomerate and breccia of east slope of Urals

Correlation with America.

Tschernyschew regards the McCloud limestone of the Shasta, California, region as the homotaxial equivalent of the Omphalotrochus horizon of the Ural and Timan. Further, he agrees with Professor Smith that this limestone is to be referred to the Lower Coal Measures. The fossils of the lower beds of the Pitt formation "remind one mostly of the Cora horizon of the Ural and Timan." "As to the analogues of the Schwagerina horizon it is difficult to state anything positively, although the extensive Pitt shales (about 2000 feet) may in part represent these beds of the Ural and Timan" (p. 700). Concerning the Robinson beds of Diller he states that "their age is near that of the Ural-Timan Cora zone."

Regarding Cummins's Texas section, this author says: "With some probability the Canyon and Strawn beds may be considered as analogous to our Ural-Timan Cora horizon, the Cisco and Albany beds to the Schwagerina zone. This is seen in the interesting paleontologic data obtained by Cummins and White in the Wichita and Clear Fork beds which overlie the Albany formation. The fauna gathered in the upper portion of the Wichita and in the lower part of the Clear Fork according to its development may be regarded as near that of the Artinsk of east and north Russia" (p. 702).

According to Prosser's work, Tschernyschew correlates the Kansas sections as follows: "The Wabaunsee and Cottonwood beds I have seen while on an excursion in Kansas in 1891, the former in the railroad quarry at the station Manhattan, and the latter in the Ulrich quarry in the same village. I should prefer to correlate both with the Cora horizon of east and north Russia. The Neosho beds and probably also the lower portion of the Chase series appear to be analogous with the Schwagerina horizon of Russia, and the remainder of this as well as the Marion beds must be regarded as homotaxial with the Russian Permo-carbon and the lower Permian. Finally, the Wellington and Cimarron beds may represent the lower red colored Permian series of east and north Russia" (p. 703).

"In Missouri and Iowa the character of the Upper Carboniferous sediments approaches the type developed in the Donetz basin,* and as in this region of Russia so in these states the Coal Measures were deposited in a relatively great sea closed toward the east, north, and south, that had connection only in

* For a detailed exposition of the Lower (C_1), Middle (C_2) and Upper (C_3) Carboniferous lithological and biological sequence, see Tschernyschew and Loutonguin, in Le Bassin du Donetz (Guide des Excursions, VII, Congrès Géol. Internat., 1897, Pt. XVI).

the west and southwest with that of the widely extended Upper Carboniferous sea of western North America." The Mississippian series "represents the entire lower and in all probability also a portion of the Middle Carboniferous divisions of Russia. . . . As has been stated above, the Wabaunsee beds are to be regarded as near the Cora horizon; we can not therefore ascribe a younger age to the Des Moines series, and they are in all probability at least in part equivalent to the Omphalotrochus horizon" (pp. 704–5).

"The Donetz type of sedimentation is still more typical in the profiles of the states Illinois, Ohio, and Kentucky. . . . At present one can only point out that a portion of the Upper Coal Measures of these States in all probability represents the beds of the Donetz basin, which on the basis of the latest researches may be regarded as the analogues of the Artinsk deposits of the Urals."

Tschernyschew then sums up his conclusions in the following table:—

<table>
<tr><th>Ural and Timan</th><th>California, Nevada, Utah, and Colorado</th><th>Texas and Arkansas</th><th colspan="2">Kansas, Nebraska, Iowa, Missouri</th></tr>
<tr><td>Artinsk deposits</td><td>Shale and shaly limestone of the Wasatch Mountains and their pelecypod fauna</td><td>Wichita and Clear Fork beds</td><td colspan="2">Marion beds
Chase beds</td></tr>
<tr><td>Schwagerina horizon</td><td>Light colored limestone of the Upper Carboniferous</td><td>Albany and Cisco beds</td><td colspan="2">Neosho beds</td></tr>
<tr><td>Cora horizon</td><td>Lower portion of Pitt shale series. Robinson beds. ? Weber quartzite</td><td rowspan="2"></td><td colspan="2">Missouri series and Cottonwood beds of Kansas and Nebraska
Wabaunsee beds
Oread limestone and Osage shales of Kansas</td></tr>
<tr><td>Omphalotrochus horizon</td><td>McCloud limestone
Upper portion of Wasatch limestone</td><td>Canyon and Strawn beds</td><td>The series from Garnet to Oswego limestones of Kansas</td><td>Des Moines beds of Missouri</td></tr>
</table>

In this connection, it may not be amiss to give the opinion of one who has now devoted ten years to a study of American Carboniferous faunas, and who has had the great advantages of the U. S. Geological Survey,—Dr. George H. Girty.

"Tschernyschew also correlates the Russian section with that of the Mississippi Valley. His correlation may be correct, but the Pennsylvanian faunas of the latter area are so widely different from those of our Western States which the Russian ones most closely resemble, that, in the opinion of one who has had some acquaintance with both types, a precise correlation is, in our present knowledge, impossible. The beds placed in alignment by Tschernyschew contain faunas so widely dissimilar that it seems an act of temerity to group them together. The evidence for so doing consists in part of the occurrence of certain American species in the Russian faunas, but the identifications, if one may judge by the figures given, in some cases are questionable and in others consist of such long-ranged types that in view of the really small percentage which these forms bear to the entire fauna, the evidence appears of diminishing significance the more critically it is examined" (3, p. 24).

Part II. The Work of Noetling.

1. Ueber das Verhältniss zwischen Productuskalk und Ceratitenschichten in der Saltrange, Indien. Von Fritz Noetling. Centralblatt für Min., Geol. und Pal., 1904, pp. 321-327.

2. Ueber Medlicottia Waag. und Episageceras n. g., etc. Von Fritz Noetling. Neues Jahrb., Beil.-Band XIX, 1904, pp. 334–376.

3. Ueber das Alter der Otoceras-Schichten von Rimkin Paiar (Painkhanda) in Himalaya. Von Fritz Noetling. Neues Jahrb., Beil.-Band XVIII, 1904, pp. 528–555.

The first of these papers is a short summary of an earlier, very important and extensive discussion by the same author (4. *Beiträge zur Geologie der Salt Range*, etc., Neues Jahrb., Beil.-Band XIV, 1901, pp. 369–471), describing the sequence of the horizons closing the Paleozoic and their unbroken succession into the well-developed Lower Triassic of India. Noetling's work has been assailed by one of the foremost geologists of Europe, and as the proper correlation of the Productus-limestone with European horizons affects the various formations composing the Permian system, it is well for Americans to become acquainted with these latest works, especially since Asiatic faunas are now known in southwestern Texas, California, and Alaska.

Noetling states: "Upon the Cambrian beds of the Salt Range there lies discordantly a sedimentary complex, followed by a series that Koken has established as of Jurassic age, in which there is no evidence of discontinuity, although during its deposition at various times very different physical conditions must have occurred.

"On the basis of origin, one can separate this sedimentary complex into three divisions of varying thickness, namely:

"An upper, pure marine
"A middle, glacio-marine } division.
"A lower, glacial

". . . This arrangement is intended only to express the relative participation of ice and sea-water in these deposits. Nowhere do we see a stratigraphic break or discordance; through local intercalations of drift horizons, the lower glacial deposits, the stratified beds, and the Conularia layer are closely united with the glacio-marine division (Olive-sandstone and Lavender-clay), and from the latter there occurs a very gradual transition into the pure marine division.

"Again, three very unequal faunal divisions may be distinguished, namely:

"An upper division: characterized by an abundance of Ceratites.

"A middle division: characterized by an abundance of Paleozoic brachiopods and sparingly of Ammonites.

"A lower division: thus far without such fossils.

"These three faunistic divisions do not wholly agree with the three genetic sections. The lower division without fossils is of course in harmony with the glacial division, but the middle section embraces the glacio-marine and the lower portion of the marine divisions, while the upper member includes the upper part of the marine section. The following table will make this clear:—

"Genetic divisions	Faunistic divisions		Stratigraphic divisions
Pure marine beds	Characterized by the absence of Paleozoic brachiopods and the appearance of a great abundance of Ceratites	Paleozoic brachiopods absent. Ceratites occurring in abundance	Ceratite beds
	Characterized by the retreat of the Ceratites and the appearance of an abundance of Paleozoic brachiopods	Paleozoic brachiopods abundant. Ceratites rare	Productus limestone
Glacio-marine beds		Paleozoic brachiopods unknown Conularia fauna	Lavender-clay Olive-sandstone
Glacial beds	Without fossils	Without fossils	Bowlder clay"

"The stratigraphic divisions represent the four or five great natural groups into which the Permian system of the Salt-Range is readily divisible, on the basis of the paleontological, lithological, and genetic characteristics."

"Naturally of greatest importance are the two groups of the upper marine division—the Ceratite beds and the Productus-limestone—for if the age of either of them can be satisfactorily determined, it follows that the age of the other is also fixed. In a general way, the age of these two groups is already established: The Productus-limestone, with its very remarkable abundance of Paleozoic Brachiopoda, must belong in the Paleozoic, while the Ceratite beds having the Ammonites characterized by Ceratite suture lines must be referred to the Triassic. However, the Productus-limestone was regarded as Carboniferous until the detailed description of the fauna by Waagen taught that this view must be decidedly modified. On my first trip to the Salt Range I noticed the gradual transition from the Productus-limestone into the Ceratite beds at Chideru; later I was able to extend this observation through the profile in the Chuas ravine, near Virgal; here can be plainly seen the individual lithologic members of the Productus-limestone and the Ceratite beds in most intimate succession. . . . Because of the indisputable succession at these two places I argued as follows: Such an intimate connection of Paleozoic and Triassic can only exist near the dividing line between the Permian and Triassic; if the Ceratite beds belong in the Triassic, then the underlying Productus-limestone must fall into the Permian, and accordingly, on account of the individuality of its fauna, it must represent but a single division of the Permian, but can not at the same time be the equivalent of both the Zechstein and the Rothliegendes."

The author then makes comparisons with other Indian Triassic regions, and also discusses the possibility that the Productus-limestone may be Upper Carboniferous. He concludes that if the Ceratite beds of the Salt Range are not Triassic, then the entire lower Trias is absent in the Himalaya. He maintains that the possibility of the Triassic being transgressive upon the Upper Carboniferous is excluded, because the transgression would then fall in the middle of an undisturbed sequence, i. e., in the Upper Productus-limestone. Further, if these deductions are not correct, then no reliance can be placed on the development of the suture lines of ammonites for the determination of geologic age (see below for his conclusions resulting from his studies on *Medlicottia*).

Noetling holds that there was a faunal transgression from the Urals, but that the time of its spreading was at about the middle of the Permian. "While this fauna was expanding radially, one can readily believe that the peripheral parts of

the transgression were younger than those of the pivotal region. In transgressions, one has to calculate not only with two dimensions, but also with a third, because a species may occur in geologically older beds near the center than at the periphery, where it may be found unchanged in younger deposits. . . . . It may be assumed that at the time of the Upper Carboniferous in the region of the present Urals, there existed an extended ocean, whose boundary was pushed toward the south and southeast (Uralic transgression). This transgression was not of a catastrophic or sudden nature, but was slow and continuous through a long period of time. The fauna spreading with the transgression passed, at least in part, unchanged into younger deposits; while in the outermost boundaries of the transgression, in the Salt Range and in the Himalaya, there occurs a series of forms in beds that are younger than the same species found in the central region. This crudely stated hypothesis naturally collides, of course, with the theory of guide-fossils (Leitfossilien), but my long-continued studies in India, namely, in respect to the Tertiary fauna, have more and more convinced me that the rigid theory of guide-fossils, valuable as it is within restricted areas, always proves disappointing when applied to greater, more widely extended regions."

In the author's larger work of 1901, cited above (4), he fully presents his views regarding the sequence of the Indian Permian and Triassic sections and their correlation with that of Europe. Noetling, however, recognizes that the difficulties are great, for he states: "If the Permo-Triassic formations of the Salt Range had first been studied, it would never have occurred to anyone to draw a line in this unbroken series and to apply to the divisions two names. One would have regarded the series as a unit, which it is. . . . . If from these formations one had proceeded to seek the European equivalents, they would have been hard to force into the scheme framed for the Salt Range. Speculation of every sort would probably have been resorted to. I now find myself in an analogous position in forcing into the European scheme the Permo-Triassic series of the Salt Range, and if it is to be employed in this case then one must make a purely artificial separation" (4, p. 458).

From this work, the table of Plate I is compiled, giving the sequence of the formations, their terminology, thickness, and correlations with European standards; the Himalayan section is added from Noetling's paper here numbered 3.

The second of these papers cited deals with the very important Permian ammonite *Medlicottia*. The genus is here studied in considerable detail and comparisons are made between the European and Indian species. The American forms are

not discussed, these being left to Prof. James Perrin Smith. In regard to the stratigraphic and evolutional conclusions attained by the author, he states:

"The views here presented are proved partly by ontogenetic, partly by phylogenetic examinations and observations, and therefore they may to a certain extent be depended upon. I must, however, note the assumption on my part that the Sicilian Fusulina-limestone is older than the Artinsk [=Permo-Carb. of the Russians] horizon, and again that the latter is older than the Productus-limestone of the Salt Range. By following out this assumption and comparing the various suture lines with one another, I obtained positive results which were proved by the development of the suture lines of *M. orbignyana*. This especially applies to the divisions of the external saddles" (p. 354).

"In this connection I would [first] like to point to an observation, which in spite of its scantiness permits of wholly unsurmised deductions regarding the climatic conditions at the close of Paleozoic and the beginning of Mesozoic time. In an earlier work I had the opportunity of propounding the question—Is the abundant appearance of *Productus* possibly connected with a cooler temperature of the sea-water?" [In Neues Jahrbuch, 1896, II, p. 86, this problem is stated as follows: "In India at least, but more particularly in the Salt Range, there was a glacial period at the beginning of Permian time. It would be interesting to examine the evidence to see if the great abundance of *Productus* has any connection with the cooler temperature of the sea-water."]

"A greater knowledge of the Paleozoic deposits of the Salt Range has given undoubted evidence of the existence of a Glacial Period at the beginning of Permian time, which deposits locally were laid down in the sea. [For a full bibliography and a good description of the late Paleozoic glaciation of India, see Noetling, Neues Jahrb., 1896, II, pp. 61–86.] In other words, this sea must have been one with a low temperature. Subsequently, in this sea was deposited the Productus-limestone, and the conclusion is not probable that the temperature of the water rose during the melting of the glaciers and the introduction of the *Productus*-fauna. In the Salt Range, therefore, this fauna is to be regarded as an arctic one.

"The studies of *Medlicottia* have shown that *M. primas* Waag. is in all probability to be regarded as a descendant of *M. orbignyanus* Vern. sp. of the Artinsk horizon. One can picture to himself the condition whereby the Medlicottias migrated from north to south (more correctly from northwest to southeast) at the same time that they passed into higher beds.

"If this conclusion is correct, i. e., the fact that a migration of the Ammonite world from north to south took place toward the end of the Permian, then, I ask, is it not conceivable that the *Productus*-fauna accustomed to a cold sea was, in consequence of the raising of the general temperature of the water, driven from its original northern habitat toward the south, where shortly before the disappearance of the Permian ice period it found the required normal temperature? Is it not further conceivable that, with a continued increase in the temperature of the sea, which under some circumstances may have occurred very rapidly, the Brachiopod fauna, also, may here have been suddenly exterminated, while the Ammonites, apparently better adapted to warmer water, developed in a most remarkable manner? Is it not, moreover, conceivable that the end of Paleozoic time was characterized by a probable rapid increase in temperature which spread itself from north to south? If this hypothesis is correct, we must then assume that the dividing line between Paleozoic and Mesozoic time is marked by a change of temperature which spread from the northern hemisphere, thus forcing the Paleozoic Brachiopoda southward, where for a short time in a suitable medium,—a sea cooled by the Permian glaciers, they attain a wonderful development, and then die out when the average temperature exceeded that beneficial to them" (pp. 375–6).

These suggestions of Noetling's are of the greatest interest. However, as *Medlicottia* occurs in Texas in association with an undoubted Upper Carboniferous fauna of the type so well known in the Mississippi valley, the question arises—Are not these the oldest Medlicottias? If so, then the further question is raised—Was not the migration east and west through the great mediterranean Thetys instead of from north to south? In 1901, Noetling (4, p. 457) explains this change of fauna on the basis of change in the depth of the sea. He states: "The Brachiopoda of the deeper waters died out and are replaced by the Ammonites, lovers of shallow waters and flat coasts."

It is the impression of the reviewer that, until more is known in regard to the extremely interesting Productus-limestone fauna of the El Paso, Texas, region and similar or Artinsk faunas from California and Alaska, no safe deductions as to paths of migration can be made.

From the third paper by Noetling, on the Otoceras horizon, is gleaned the following:—

"In a treatise on the divisions of the pelagic Trias, Mojsisovics, Waagen, and Diener, supported by the statements of Waagen that there exists a hiatus in the Salt Range between the uppermost Permian and the lowest Trias, have denied the

existence of the Otoceras beds or their equivalents in this part of the Trias sea.

"I had serious doubts about this conclusion, for on my visit to Chideru in the Salt Range I was convinced that there is here a gradual transition from the Upper Productus-limestone (Permian) to the Ceratites beds (Trias).

"This observation is not new, for at different times Wynne has pointed out the gradual passage in the sequence of the beds from the Productus-limestone to the Ceratites beds, but his statements have unfortunately received too little attention" (p. 529).

On this visit Noetling looked for the Otoceras beds at the base of the Ceratites zone below the Ceratites-limestone, but did not find this diagnostic fossil. To his great surprise he did find what he took to be an *Otoceras* in the Ceratites-shale, i. e., above the Ceratites-limestone. On his return to the museum at Calcutta, however, the fossil proved not to belong to this genus. After a further dissection of the Himalaya section he states: "In the Himalaya the Otoceras beds lie immediately below the Hedenstroemia beds. Accordingly, in the Salt Range, either the Otoceras beds or their equivalents must be looked for immediately beneath the Ceratites beds. As, however, in the Salt Range, immediately beneath these beds lies the Permian (Upper Productus-limestone = Chideru group) it follows that we have to seek for the equivalents of the Otoceras beds in the Salt Range in the Upper Productus-limestone, probably in my *Euphemus indicus* zone, but over the zone with *Episageceras wynnei*." In spite of careful collecting none were found, and he concludes: "According to our experience we almost doubt the occurrence of *Otoceras* in the region of the Salt Range." The two regions have a different stratigraphic sequence with somewhat different faunas, and it may be that they were separated from one another by a submerged barrier (a rising anticline) not wholly preventive of intermigration.

Then follows a long discussion of the apparently complete transition zone in the Himalaya, between the Productus-limestone and the Ceratites beds, and considerable detail regarding the included fauna as well. This discussion is entirely too long and too detailed to be summarized here, but Noetling's views are clearly presented in two correlation tables, one of which has been added to the table given on Plate I.

[To be continued.]

PLATE I

Horizons and Zonal Names

			Salt Range			Himalaya	
			Discordance			Region of Spiti	Region of Niti
Triassic	Buntsandstein	Scythian stage, Upper	Upper Ceratite limestone	Zone of *Stephanites superbus*	Maximum thickness	Not known as yet	Dark limestone of Byans
		Scythian stage, Middle	Ceratite sandstone	Zone of *Flemingites flemingianus*	220′	Hedenstroemia beds	Hedenstroemia beds
			Ceratite clay	Zone of *Koninckites volutus* Zone of *Prionolobus rotundatus*			
		Scythian stage, Lower	Lower Ceratite limestone	Zone of *Celtites* (?) sp.		Zone of *Meekoceras lilangense*	Zone of *Prionolobus noetlingi*
Permian	Marine Neodyas	Zechstein, Thuringian stage	Chideru group or Upper Productus-limestone Brown earthy limestone	Zone of *Euphemus indicus* Zone of *Episageceras wynnei* 50′ Zone of *Bellerophon impressus*	300′	Zone of *Ophiceras tibeticum*	Zone of *Ophiceras tibeticum*
				Zone of *Cyclolobus oldhami* 180′ Zone of *Derbya hemisphaerica* Zone of *Productus lineatus* 70′		Zone of *Otoceras woodwardi*	Zone of *Episageceras dalailamæ* Zone of *Otoceras woodwardi*
	Marine Palaeodyas		Virgal group or Middle Productus-limestone Light colored flinty limestone	Zone of *Xenodiscus carbonarius* 20′ Zone of *Lyttonia nobilis* 130′ Zone of *Fusulina kattaensis* 50′ No *Fusulina* occur higher than this stage	300′		
			Amb group or Lower Productus-limestone Dark, sandy limestone	Zone of *Spirifer marcoui* and *Fusulina*	200′	Dark Productus slates with *Cyclolobus oldhami*	Dark Productus slates with *Productus abichi*
	Glacial Palaeodyas	Pandschabian stage	Warcha group	Lavender clay Speckled sandstone	250′		
	Rothliegendes		Dandote group	Olive sandstone Zone of *Conularia laevigata* In shale Zone of *Eurydesma globosum* In shale Olive sandstone	200′		
			Talchir group	Bowlder-clay	150′		
			Discordance				
			Cambrian				

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 carboniferons 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 *Ammonea*. 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. *lawrenciana*, *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., *Myophoriopis Kraffti* 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: *Enteletes*, *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*, *Enteletes* 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, *Enteletes*, *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 ¼ to ⅜ 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 Lyttoniidæ. 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 tratigraphic 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 enviroment, 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 Chideru—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 Lyttoniidæ 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 Lyttoniidæ 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 Lyttoniidæ, but as well of the Richthofenidæ 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.