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A SYMPOSIUM ON THE CLASSIFICATION AND NOMENCLATURE OF GEOLOGIC TIME-DIVISIONS.

THE infelicities which arise from the uncertain use of terms in the discussion of geologic time-divisions are more or less fully appreciated by every working geologist. The peculiar difficulties which the varying and often inconsistent use of terms imposes upon the student of geology when he leaves the narrow confines of his text-book and tries to use the current literature of the science, can only be realized by those teachers who have encouraged this broader method of study and conscientiously feel responsible for the results. Not every text-book, even, is consistent with itself. It is too much to insist that it should be consistent with general usage until a consistent general usage is established. The importance of a more systematic classification of time-divisions and rock-series has been recognized by the international congresses of the last two decades. The limited results that have been reached by the efforts of these congresses seem to indicate that the problem must be worked out by gradual approaches through tentative efforts. It perhaps also indicates that the problem must be in large part worked out in the great provinces or in the individual continents separately as a preliminary to intercontinental coördination. Not a few geologists who heartily sympathize with the effort to secure more uniform and better practice are yet quite unwilling to have a rigid system imposed by the vote of a body of so uncertain composition as

an international congress. Quite aside from doubts connected with such an enacting body, there are those who question whether we have reached that stage in the development of interpretations and correlations which warrants the formal adoption of a universal system of classification and nomenclature. Fully sympathizing with both these classes, we none the less feel that these considérations only emphasize the importance of those preliminary and tentative efforts through whose agency a satisfactory system is to be worked out in time by the method of concerted trial and continued rectification. Especially does it seem important to proceed as fast as may be with the evolution of a system appropriate to our own continent as a preliminary to the establishment of an intercontinental system.

Certain phases of a system of nomenclature involve little more than a choice of terms. To this extent only a consensus of preference is needed to inaugurate a common practice which shall become conventional. In most cases, however, the choice of terms is connected with a choice of ideas, and a consensus is less readily reached. Whether a community of preference can now be reached or not, it can scarcely be questioned that we should work toward such a community, if possible, rather than away from it. We appear to have been receding from uniformity, rather than approaching it, for the past two decades. The result is a disturbed practice and a confusion of terms infelicitous alike to geologist, to teacher, and to student.

The more important phase of the question lies back of the selection of terms and relates to the questions: What divisions, or what order of divisions, shall be chosen for formal nomenclature, and upon what criteria shall the divisions be determined? Granting that these questions cannot be answered finally at present, or in the near future, it is still urgent to inquire: By the use of what system, provisionally adopted for current use, can we best work on toward better systems in the future?

To draw out opinion on the subject, a series of questions was prepared by one of the editors of this JOURNAL (Professor Salisbury) and submitted to several American geologists with a

view to inaugurating discussion. The questions were made specific to invite definiteness in the replies. They were made to overlap somewhat to facilitate specific answers to different aspects of the subject. It was not intended to specifically advocate the scheme presented, but merely to submit a tangible sketch for discussion. A portion of the replies are printed in this number. The discussion of the subject by others who may be interested is invited. The questions submitted are as follows:

1. What classification of time (and terranes), say to the third or fourth division, seems to you best adapted to North America? If you are ready to express your opinion concerning such a classification to the second division, but not farther, please do so.

2. To what extent is it desirable to adhere to European standards, if some other classification is better adapted to North America?

3. What noun should be used in connection with the adjectives *Palæozoic*, *Mesozoic*, etc., 1° when time is meant, and 2° when formations are concerned? For example, Palæozoic *era?* Palæozoic *group?*

4. What noun should be used in connection with the primary subdivisions of the Palæozoic such as Cambrian, 1° when time is meant, and 2° when formations are concerned? For example, Cambrian *period?* Cambrian *system?*

5. What is the best noun to be used in connection with divisions of the third order, such as Lower Cambrian, Middle Cambrian, etc.? For example, Lower Cambrian *epoch?* Lower Cambrian *formation?*

6. Ditto for divisions of the fourth order.

7. Would you approve of the separation of the sub-Carboniferous and the Permian as divisions coördinate with the Carboniferous proper, the Devonian, etc.

8. If you approve of the separation of the sub-Carboniferous from the Carboniferous, as a division of the second order, would you approve of retaining the name sub-Carboniferous or Lower Carboniferous, or would a new name be better, say Mississip-

pian? The repetition of terms involved, if the term sub-Carboniferous or Lower Carboniferous and Carboniferous continue to be used as now, is so great as to be very confusing to students. Those who have not dealt with students beginning the study of historical geology may not be aware of the difficulty involved in such a system as the following:

Carboniferous,
Permian,
Carboniferous,
Sub-Carboniferous.

9. Would you approve of the separation of the Cretaceous into two divisions coördinate with each other, and each coördinate with such divisions as the Devonian?

10. If so, would you approve of the retention of the names Lower Cretaceous and Upper Cretaceous, or should one of these divisions, presumably the Lower, receive a new name, say Comanche?

11. How should the Cenozoic be subdivided?

12. What is the advantage of the term *Canadian*, and the corresponding *Trenton*, in the following classification?

Ordovician - -	Trenton	Hudson River	
		Utica	
		Trenton	
	Canadian	Chazy	
		Calciferous	

Why not instead?

Ordovician - - -	Hudson River
	Utica
	Trenton
	Chazy
	Calciferous

13. Will you express your opinion concerning the following outline where the divisions are carried to the second order?

Era (for time) Group (for rocks)	Period (for time) System (for rocks)
Cenozoic - -	Pleistocene
	Pliocene
	Miocene
	Eocene

Mesozoic - -	Cretaceous (Upper) Comanche (Lower Cretaceous) Jurassic Triassic
Palæozoic - -	Permian Carboniferous Mississippian (sub-Carboniferous) Devonian Silurian Ordovician Cambrian
Proterozoic - -	Keweenawan Upper Huronian Lower Huronian
Azoic - -	Archæan

14. What would you say to this plan of classification:

Era - - -	Group
Period - - -	System
Epoch - - -	Series
Stage - - -	Formation

CONTRIBUTION BY JOSEPH LE CONTE.

I hereby give answers to your questions as briefly as possible:

1. I am not prepared to go further than divisions of the second order.

2. European standards, as first in the field, must be followed as far as possible, but should be modified, if necessary. But eventually we must have a world standard, at least for divisions of first and second orders.

3. I think — Era and Group are best.

4. " " Period and System are best.

5. " " Epoch and Series are best.

6. " " Stage and Formation are best.

7. (*a*) *Sub-Carboniferous* is certainly coördinate with Carboniferous proper, but I do not think that *Permian* is. Witness the tendency to unite Carboniferous and Permian under Permo-Carboniferous.

(*b*) But I much doubt that these are coördinate with *Devonian.*

8. "Mississippian" serves our American purposes well, but, if used, ought to be coupled with Lower Carboniferous as synonym, as you have done.

9. Cretaceous ought to be divided into two coördinate divisions, but I do not think these are at all coördinate with Triassic, Jurassic, or Devonian. They must be regarded as sub-periods.

10. I think it best, therefore, to retain the names Lower and Upper Cretaceous; but, if a new name is used for the lower division, why not call it "*Shasta.*" It was certainly first recognized there.

11. I am in favor of the fourfold division of Cenozoic you propose, although I fully appreciate the reasons for uniting Miocene and Pliocene into Neocene. Tertiary and Quaternary might well be abolished, as Primary and Secondary have already been.

12. I see no sufficient reason for the names Canadian and Trenton as sub-periods. Better divide Ordovician at once into epochs, as you suggest.

13. I like your schedule of divisions of first and second orders except as regards the Cretaceous and Carboniferous, as already explained. Also, I do not like the term "Azoic," although not prepared to suggest anything better.

14. I fully endorse your general plan of classification for time and strata.

JOSEPH LE CONTE.

CONTRIBUTION BY G. K. GILBERT.

So long as historical geology continues to be a living science no definite system of nomenclature can hope to be permanent, nor even, perhaps, to give temporary satisfaction to a majority of geologists. Nevertheless, as intimated by the JOURNAL's circular letter, teachers and geological surveys must have definite systems, and so the task of making and remaking them is a sort of necessary evil.

(Questions 1 and 2.) Though time is universal, faunas and histories are more or less local. A refined time scale cannot be used to advantage in the correlation of formations widely separated. Therefore, only the major orders of a time classification should be treated as universal, and the minor should be recognized as local. I suggest that the line of discrimination be arbitrarily drawn between divisions of the second and third ranks, periods and epochs.

Pursuant to this suggestion, I propose the following auxiliary criterion for periods (not replacing but supplementing other criteria): Periods should have such magnitude that their application to the correlation of formations anywhere in the northern hemisphere will yield areas of certainty which are large as compared to the unavoidable zones of doubt.

This criterion is used in the selection of the subjoined scheme of periods, but is subordinated to other considerations in the admission of Pleistocene and Algonkian. Jurassic and Triassic are given separate place despite their broad zones of doubt when applied to American terranes, because the breadth of those zones is due to dearth of the most important data for correlation, marine fossils.

Periods.

12. Pleistocene (or Quaternary).
11. Tertiary.
10. Cretaceous.
9. Jurassic (or Jura).
8. Triassic (or Trias).
7. Carboniferous.
6. Devonian.
5. Silurian.
4. Ordovician.
3. Cambrian.
2. Algonkian.
1. Archæan.

(3.) Four time-nouns have been used in this rank by various authors: *Era*, *age*, *eon*, and *time*. *Time* cannot be spared from its general sense. Of the others *eon* alone has a good connotation for this place; its untechnical meaning always includes long duration.

Group is not well placed in this rank. Prevalent American usage, which puts it next above the unit *formation*, is in harmony

with the ordinary meaning of the word,—an aggregate of individuals (not an aggregate of aggregates).

(7.) No.

(7, 8.) I like Mississippian as the title of an American subdivision of the Carboniferous period. There is need of a complementary, coördinate, American, geographic name (or names).

(9.) No.

(14.) I prefer:

Eon	- - -	System (or Series).
Period	- - -	Series (or System).
Epoch	- - -	Group.
Stage (or Age)	-	Formation.

(Comment on 5, 8, 10, 13.) The adjectives of space relation, *Lower* and *Upper*, should not appear in a time scheme. The prefixes *Eo-*, *Meso-* and *Neo-* (proposed for a somewhat different use by Williams) seem appropriate for the indication of indefinite portions of any time unit. For definite parts separate geographic names are preferable. G. K. GILBERT.

CONTRIBUTION BY WM. BULLOCK CLARK.

I think that the questions, which you have raised regarding the use of terms in geological classification, are most timely. If a discussion of the subject can aid in bringing about some unanimity in the employment of these terms on the part of geologists, you will have performed a great service.

I am inclined to take the position that, from the very nature of the case, a universal system of stratigraphic equivalents cannot be employed for the chronologic terms. The chronologic divisions, as we all recognize, are at best highly artificial, while the stratigraphic divisions are natural and definitely determinable units. The term "formation," for example, has come to be rather widely used to embrace deposits formed under approximately similar conditions whatever the time element involved, and may or may not be separated from overlying or underlying formations by an unconformity.

Accepting the chronologic terms which you have adopted,

and which, I think, cannot be improved upon, certainly to the third division — viz., era, period, epoch — it may be possible to find the formation as the equivalent of a portion or the whole of any one of these time divisions, excepting, perhaps, the era. To attempt to restrict it, therefore, in all instances to any chronologic division, large or small, would seem to me unwise.

Furthermore, I think that a different series of names should be applied to the formations and their subdivisions than to the time units. I should speak of the Palæozoic era or time, the Cambrian period, and the Upper Cambrian, or better, the Neo-Cambrian epoch, but of the Potsdam formation or the Shenandoah formation, the latter representing portions of the Lower Silurian as well as Upper Cambrian, and affording a good example of the formational unit. I prefer the prefixes Eo-, Meso- and Neo- to designate the epochs, as proposed by Williams. I think the term Stage more applicable to a division of a formation, whether characterized by a distinct fauna or not, than to a time unit.

In reply to your questions seven and eight regarding the later divisions of the Palæozoic, I should employ the chronologic terms Carboniferous and Permian, the former divided into Upper and Lower, or Upper, Middle and Lower Carboniferous, as the case might be. To be consistent the terms Eo-, Meso- and Neo-Carboniferous should be used. The Upper Carboniferous may be represented by Coal Measures made up of one or more formations; the Lower Carboniferous may be represented as in the central United States, by the Mississippian, or, as I should prefer, the Mississippi Group, made up of various formations. I should personally object to the use of the term Mississippian in a chronologic sense, unless the period term Carboniferous was to be permanently divided and the resultant divisions raised to the period rank. The reasons for such change, however, do not seem to me to be sufficiently strong. I think the widely extended difference in facies represented in the Upper and Lower Carboniferous tends greatly to accentuate the two divisions of this period.

These same reasons seem to me to apply equally well to the Cretaceous. Although there is a very considerable difference between the upper and lower divisions, it does not seem to me sufficiently great to warrant their elevation to equal rank with Devonian, Carboniferous, etc. I should, therefore, employ Comanche in its original sense as a stratigraphic term, and, as several formations are clearly recognized within the limits assigned to it, I should be inclined to speak of the Comanche Group.

I should prefer to divide the Cenozoic into Eocene, Neocene, and Pleistocene as the most widely recognizable time units, placing under the earlier term Eocene the subsequently named division Oligocene of von Beyrich and uniting Miocene and Pliocene into Neocene.

I can see little advantage in the use of the terms Canadian and Trenton, except as group names, to include the Calciferous and other formational divisions.

I prefer the use of Lower Silurian to Ordovician, as I do not think the term Silurian of Murchison can with propriety be restricted to the Upper Silurian. If the Upper and Lower Silurian are to be raised to period position, and Ordovician used, I think some other name should be substituted for Silurian.

WM. BULLOCK CLARK.

CONTRIBUTION BY S. W. WILLISTON.

I am greatly pleased with your attempt to reduce some kind of order out of the chaos that has been made in geological nomenclature. I think no one but the actual teacher of historical geology can appreciate the amount of confusion that now exists and the vexation that it causes both teacher and pupil.

To the first five questions I am not prepared to offer suggestions except this, that it will make very little difference what terms are used for the time and formation, provided there is uniformity. I am ready to accept and teach any system that receives the approval of writers on these subjects, and is used with tolerable fixity and uniformity.

7. To this proposition I would desire to enter a vigorous protest. Having worked in Kansas, where the Permian is best represented in this country, I can see no good grounds whatever for distinguishing between two groups in respect to which neither the palæontologist nor the stratigraphist can determine where the one begins and the other ends. Palæontologically there is nothing of sufficient importance to warrant the division into primary periods. It is true that, so far as we now know, the reptiles began in this time, but every palæontologist confidently expects that they will be found in the true Carboniferous, and in fact they have been found in Kansas in strata that are yet in dispute. Knowing less of the sub-Carboniferous, I cannot give an opinion here, but I do not believe there are any better grounds for division than between the Carboniferous and the Permian.

Classification of the time periods of the earth must inevitably follow the same rules as those applied in the classification of animals and plants, which in the end becomes one of convenience, chiefly. If we increase the number of primary divisions, as the tendency seems to be, the number will at last become so large that some future classifier will insist upon reuniting many of them under new and undesirable names. The chief divisions should represent, so far as possible, time periods of equivalent importance, and to say that the Permian period is an equivalent of the Carboniferous, or the Silurian, is certainly incorrect. Personally, I would rather see the Trias annexed to the contiguous divisions!

8. I should much prefer to see the name Carboniferous applied to the primary division and distinctive names given to the three subdivisions. There is a *very* great, almost intolerable, objection to using the name Carboniferous in two senses, or even the Carbonic and Carboniferous. I very much hope that the name Mississippian may be given to the lowest group, some good distinctive term to the intermediate, as Coal Measures, and Permian applied to the uppermost.

9. For many of the same reasons already given for the

Permian, I strenuously object to the subdivision of the Cretaceous into two primary divisions. Certainly, so far as vertebrate palæontology is concerned, there is no good reason for the division, and there are many opposed to it. I would rather prefer Upper and Lower, for the divisions of the Cretaceous, but would willingly see such terms as Platte and Comanche used.

11. I would prefer to have the Cenozoic divided into the Eocene, Miocene, Pliocene and Pleistocene. I believe this is the only logical system, unless, perhaps, the Oligocene is added. Nevertheless, I see great difficulty in superseding the much used Tertiary. Most assuredly there should be no distinction into "Tertiary" and "Quaternary," and, if Tertiary is used, its limitations must be widened to include the Pleistocene. This will be equally hard to do, and for that reason I believe, upon the whole, the best way is to drop the term Tertiary entirely.

14. I am quite ready to use the plan of classification given in my teaching and writings, if its use can become at all general. Fixity and uniformity are all that I ask for here.

13. The terms and divisions that I think ought to be adopted, so far as I have grounds to base my opinions upon, are as follows:

Cenozoic, - - -	Pleistocene,	
	Pliocene,	
	Miocene,	
	Eocene,	
Mesozoic, - -	Cretaceous,	Upper. Lower.
	Jurassic.	
	Triassic.	
Palæozic, - - -	Carboniferous,	Permian. Coal Measures. Mississippian.
	Devonian,	
	Silurian,	
	Ordovician,	
	Cambrian.	
Eozoic or Proterozoic,		
Azoic.		

I have done very little field or laboratory work upon the divi-

sions prior to the Carboniferous and refrain from expressing an opinion about them.

I very much prefer the use of European terms for divisions that can be correlated with tolerable exactness; otherwise distinctive American terms should be used.

I sincerely hope that you will bring some order out of what has been so confusing to both teacher and student.

S. W. WILLISTON.

CONTRIBUTION BY BAILEY WILLIS.

Your inquiries of May 5, concerning the use of certain common terms in geology and questions of classification, were duly received and have been carefully considered. In answering I beg to state that I express my personal opinion as determined by experience in practical field work and in editorial work on geologic maps.

The following answers are arranged categorically, according to the numbers of the questions to which they refer.

1. *Eras*, *Systems*. — Terms to be applied respectively to the grand divisions of time and the rocks representing them, as determined by the most important events of biologic development.

Periods, *Groups*. — Arbitrary divisions respectively of time and rocks within the eras and systems, designed to afford means of approximate designation of the position of any geologic record in the time scale. These should be applied consistently the world over according to the volume of stratigraphic evidence as checked by palæontology, but it does not necessarily follow that in North America they designate time divisions precisely contemporaneous with those distinguished in other continents.

Ages, *Series*. — Terms to be applied respectively to subdivisions of time and rocks less than period and group, but including a consistent sequence of biologic or lithologic changes without break. An age or series may include parts of two periods or groups.

Epochs, *Formations*. — Terms applied to designate the time

represented by the lithologic unit which may be mapped on a given scale and the lithologic unit itself.

Episodes for time, Lenses and Lentils or Stages for rocks.—Terms applied to local lithologic variations or limited rock masses which for purposes of discussion need to be defined, but are not of sufficient consequence to justify the distinction of a separate name.

I may briefly state my reasons for the above suggestions as follows: (1) I associate era and system because the classification is based on the broadest natural facts and is therefore systematic. (2) I associate group with period because both terms appear to me less precise and adapted to the arbitrary character of the unit thus classified. The division of time according to a scale of periods appears to me equivalent to the division of a column of mercury according to a scale of degrees to indicate temperature; whether the result be expressed in the arbitrary terms of Fahrenheit or Centigrade the fact remains unmodified. The simplest scale which will satisfy the needs of world-wide geology is to be preferred. (3) I associate age and series as both of them indicate a consistent logical sequence of events having their beginning and rounding out to an end, as in history we have the Elizabethan age and the series of events which characterize it. Age and series are natural divisions as distinguished from period and group, which are terms of the arbitrary scale. (4) I associate epoch and formation probably rather through custom than for any special reason, but I prefer epoch as a time designation to stage because the latter has a more concrete significance and might with equal aptness be applied to a subdivision of rocks. Indeed, if a geologist named to me the Medina stage, I should understand that the sandstone was referred to rather than the time for which the sandstone stands. Furthermore a stage appears to me to represent a temporary or very brief condition and to correspond in time with the term episode. The necessity for the fifth subdivision, corresponding to episode, frequently arises in detailed discussion, and is a means of avoiding complexity of nomenclature. Thus if a con-

glomerate lens appears in the Medina formation it can be referred to as the Medina conglomerate lens or episode, without burdening the discussion with a new name, which the conglomerate should receive if it be considered a formation.

2. To that extent which promotes unity of classification without contradiction of fact and no further. In case of doubt whether European standards apply to North American facts, it is better to adopt a North American standard in accordance with the facts.

3. Palæozoic era, Palæozoic system.

4. Cambrian period, Cambrian group.

5. Lower Cambrian age, Lower Cambrian series.

6. Medina epoch, Medina formation.

7. No. The multiplication of period divisions does not in my judgment tend to the advantage of geologic students.

8. The absurdity of a double meaning for any term is apparent. The usage arises from the effort at excessive subdivision in terms of periods.

9. and 10. No. This question has been several times considered, and the requirements of the case are adequately met by the use of the terms Comanche age and Comanche series.

11. Pleistocene, Neocene, Eocene.

12. I should omit Trenton and Canadian as superfluous.

13. The proposed scheme contains an undesirable number of period divisions. The sets of facts and corresponding times represented in the scheme by Pliocene, Miocene Comanche, Jurassic, Triassic, Permian, Mississippian, and Ordovician I should transfer from the list of periods to that of ages, where I think they would be adequately represented.

14. Answered under 1. BAILEY WILLIS.

CONTRIBUTION BY C. R. KEYES.

If I understand the questions rightly it would seem more logical to attempt to answer the last one first.

Uniformity of terminology is the great desideratum of working geologists. The main drawback to the adoption of any

proposed scheme appears to lie in the disinclination of most writers to make any distinction between a technical and common usage of words. Terms that already have assumed special meanings should be used only in a technical sense. For expressing ideas in which a restricted meaning is not implied there are many common terms.

In geological classification a dual scheme has come to be so universally recognized that it is difficult to imagine that any other is possible. Yet, for local successions of strata a single set of adjectives suffices to designate both the subdivisions of time and those of substance. Hence, with five orders of terms to denote the taxonomic rank of the name used—and these appear to be all that will ever be useful in practical work—we have:

Order.	For Time.	For Rocks.	Example.
1.	Era	Assemblage.	Palæozoic
2.	Period.	System.	Carboniferous.
3.	Epoch.	Series.	Mississippian.
4.	Episode.	Stage.	Kaskaskia.
5.	Hemera.	Zone.	Pentremites Godonii.

The word group, sometimes used for the largest rock division, is so thoroughly incorporated in our literature in a different sense, and is generally so loosely applied, that it seems hopeless, and in fact very undesirable, to attempt to give it, at this late day, a technical meaning. Moreover, it is far more useful now, with its present indefinite application to any selected number of beds or subdivisions, than it could possibly be in a more restricted sense. Some other title should take its place for technical purposes. It makes little difference what it is. Its general adoption is the most important feature. Assemblage, the name here given, is merely suggestive. It is somewhat ponderous, but is expressive of the grand subdivisions.

Stage is a word associated not with the idea of time, but of place. It is, therefore, more properly applicable to the fourth structural order, interchangeable, perhaps, with formation. But the latter term may be extended without confusion to crystalline

masses also. As the stages are based largely upon lithological characters and receive local geographic names, the latter are followed by such words as limestone, shale, granite, etc., thus doing away with the technical title altogether. In general the word formation seems to be best retained for use in somewhat doubtful cases, where the exact taxonomic rank is questionable, but believed to be about of the fourth order; while group refers to any of the greater orders.

The time equivalent of the stage seems best expressed by the word episode. The word Time is also appropriate, and it more exactly corresponds with the historical usage to represent a generation.

The zone is a useful subdivision of the smallest unit usually recognized in this country, The name of its time equivalent is Hemera, proposed by Buckland. The zonal classification of the Ammonite-bearing beds of the Jurassic is an example.

Assuming the ultimate aim of every scheme of geological chronology to be to provide a means of paralleling stratigraphic successions more or less widely separated geographically, a practical question arises as to how far a general classification is applicable to a given region, and how far the local plan is capable of being expanded.

While the double geological scale is theoretically everywhere balanced, in practice the time element is given precedence at the more general end of the scheme, and the rock element at the more specific or local extremity. In the present state of our knowledge general correlation farther than series is beset by many and grave difficulties, and it is doubtful whether it is feasible to extend it beyond.

So far as concerns the first two orders enumerated in the plan already given, it seems desirable, for the present, to retain the names generally applied to the different "groups," even though they are largely European in origin and are not exactly expressive of the real conditions in North America. They are so thoroughly part and parcel of our literature that it would be revolutionary to supplant them. It is better to modify their

meanings somewhat, rather than discard them altogether. Besides they have entirely lost their local original significance. They are now abstract terms. In this country the data will soon be at hand for the construction of an entirely new chronological plan, having a purely physical basis, the biological criteria being ignored altogether.

In the third order there is an overlapping of general and local criteria. To express the time factor the words Early, Mid- or Middle, and Late appear appropriate; as Early Cretaceous. The simple Anglo-Saxon names are much more preferable than the long barbarisms, produced by the Greek prefixes Eo, Meso and Neo. Simplicity of terminology should be a cardinal principle if geological science is ever to receive the popular attention it deserves. For the rock scale, Lower, Median or Middle, and Upper are useful terms to indicate in a general way the corresponding subdivisions; as Lower Cambrian, Lower Carboniferous. Or, the latter titles may be used in a somewhat indefinite way, when the exact stratigraphic limits are yet unknown.

Here the local succession begins to assume importance and the general time factor to lose it. Each geological province has its own sequence of strata. A provincial geographic name is desirable, if possible with an adjective ending. Thus, we have for the Lower Carboniferous in the Mississippi province, the Mississippian series; in the Appalachian province the Poconon series, possibly; in the Great Basin province the Aubreyan series, perhaps. The number of series is thus not fixed for any system, as locally represented, nor for different localities. Yet the epoch of all is definite. The time may come when it is desirable to have some special name to cover all the provincial series of approximately the same age, but the condition of our knowledge does not yet warrant it. It is doubtful whether it would be any improvement on the simple Lower, Middle and Upper.

An ideal feature of geological nomenclature is uniformity of endings for all terms of equal taxonomic rank. With those of the first order this method already prevails. In the case of

those of the second order a variety of different terminations exist; but it is probably not advisable now to change them. However, these names are so few in number that they are not liable to cause confusion. The provincial titles of the third order are in large part yet to be proposed. For all these an appropriate original or provincial name is suggested, with the ending *an*, if possible. This leaves the countless horde of formations, or stages, the usual units of geological mapping, the distinguishing characters of which are based chiefly upon lithology, a clear field for unchanged, local, geographic honors. The zones are named from their leading fossils.

Our information regarding the geological subdivisions is so unequally distributed that at best a very unsymmetrical classification must be endured for the present. The following seems to be the most acceptable scheme for North America:

Era.	Period.	Epoch.
Cenozoic.	Pleistocene. Neocene. Eocene	Late or Recent. Early.
Mesozoic.	Cretaceous. ———? ———?	
Palæozoic.	Carboniferous. Devonian. Silurian. Ordovician. Cambrian.	Late Mid. Early. For all.
Proterozoic	Keweenawan Huronian? Laurentian? or new name.	
Azoic	Archæan.	

For purposes of instruction the provincial scheme for rocks for the special region studied may serve as a standard.

It is desirable to adhere to European standards, or the present American standards as derived from Europe, as closely as possible until our present knowledge expands sufficiently to enable us to gradually erect new and more rational standards. The first and second orders should be as closely equivalent as

possible, and with the same names for both continents, and for the whole world. It is better to have everywhere the same terminology with approximate parallelism in meaning than different names and no means of unconscious comparison.

At the present time no series are formally recognized in the Devonian. The system is doubtless as well differentiated in this respect as the Carboniferous.

It is exceedingly doubtful whether the term Permian should be permitted to hold a place in American geological literature or classification. The original Permian is perhaps applied to a provincial series, taxonomically of the same rank as Mississippian. In America the so-called Permian is also a series and actually a subdivision of the Carboniferous. The same is true of the so-called sub-Carboniferous. It follows that neither should be coördinated with the Devonian.

The use of the term sub-Carboniferous in American geology is very unfortunate. As originally proposed, and as used for a long time afterwards, it referred to an indefinite sequence of strata extending downward from the "Coal Measures" even as far as the Trenton. As more recently used the subdivision so called would be better designated the Lower Carboniferous, the serial rank being understood, Mississippian being regarded as the equivalent provincial title as explained above. Neither Carboniferous nor any other unqualified term should be used for both system and series, or any two subdivisions of different taxonomic rank.

Canadian seems wholly out of place in the sense used unless it can be modified so as to denote a series. The use of Trenton in two different senses should be discontinued. It appears unnecessary to retain the word river in connection with Hudson —even though it has been widely used. And similar double geographic names are to be avoided.

CONTRIBUTION OF SAMUEL CALVIN.

Referring to your inquiries relative to the classification of time and terranes best adapted to North American geology, I

would say that I am disposed to be very conservative and would like to see as little disturbance as possible of terms that have met with somewhat general acceptance. The terms, *Group*, *System*, *Series*, *Stage*, and the correlative time-divisions, *Era*, *Period*, *Epoch*, *Age*, are to my mind very satisfactory. Of course any other terms would answer equally well provided geologists were agreed to use them. What we need to do, as it seems to me, is to adopt in this case the method that is in most general use, and by extending the use of it to make it more and more general until it becomes universally adopted. I would not like to see the term *Formation* used in place of *Stage*, and this simply for the reason that *Formation* is now in use as a loose, general term. Such a term is very much needed, and any attempt to change *Formation* from a loose to a precise term would be attended with great confusion. Heaven knows we have confusion enough now to contend with.

It does not seem to me to do any harm to leave the Lower Carboniferous or Mississippian as a division of the Carboniferous. The use of the term Mississippian would be an advantage; and the arrangement I would prefer, simply as a result of my attitude of conservatism, would give Mississippian the same rank as Corniferous, Hamilton and Chemung in the stratigraphy of the Devonian.

The greater part of the assemblage of strata called Permian by Prosser and the geologists of Kansas University contains precisely the same fauna as our Missourian or Upper Coal Measures, and if there is no better excuse for recognizing Permian in America than that afforded by the beds in question, then America has no Permian. At all events if these strata are Permian then the Permian cannot be separated from the Carboniferous. A large percentage of the so-called Permian fauna occurs in the coal-bearing strata of Indiana, Illinois and Iowa, that is, the fauna actually begins in what we call in Iowa the Des Moines stage, or Lower Coal Measures. Personally I see no good reason for recognizing Permian in America, but if we must in order to keep up with Europe, then the Permian must rank as a subdivision of

the Carboniferous. We might therefore arrange the Carboniferous in some such way as this :

Carboniferous	Permian.		
	Pennsylvanian or Coal Measures	Missourian.	
		Des Moines.	
	Mississippian or Lower Carboniferous	Kaskaskia.	
		Saint Louis.	
		Osage or Augusta.	
		Kinderhook.	

9. I would prefer to leave the Cretaceous undivided, being governed in this choice simply by the conservative desire to leave things undisturbed. The literature of the Mesozoic is based on the division into the Triassic, Jurassic and Cretaceous, and any change will require a long period of adjustment and will involve endless confusion. It is much easier, and just as convenient to let the Cretaceous stand as a single system and divide it into a Lower (Comanche ?) and an Upper (unnamed) series.

Cretaceous System.	Upper Cretaceous (Black Hills series)	Denver.	
		Laramie.	
		Montana.	
		Colorado.	
		Dakota.	
	Lower Cretaceous (Comanche series)	Washita	or any other arrangement.
		Fredericksburg	
		Trinity	

The whole of the Upper Cretaceous, excepting the Laramie and Denver, is well developed around the flanks of the Black Hills.

We can retain the established names in the Cenozoic and adapt our nomenclature with perfect ease to the old arrangement

by adopting appropriate stage names. We shall here need two sets of stage names, one for the marine Tertiary and the other for the fresh-water Tertiary deposits.

Cenozoic Group	Pleistocene	Recent.
		Glacial.
	Tertiary	Pliocene.
		Miocene.
		Eocene.

12. There is some advantage in retaining the terms Canadian and Trenton as names of series in the Ordovician. The faunas of the Trenton limestone, the Utica and Hudson River shales are very intimately related, and that relation should be indicated by grouping the three together as stages of a single series. The Calciferous and Chazy should similarly be grouped into one series.

I believe if you have patience to read all this that you will see how I would stand with reference to the several questions in your circular letter. Any classification is arbitrary at best. A dozen or more equally good schemes might be proposed, but we should adopt and strengthen as far as possible that which is in most general use, notwithstanding the fact that it might be improved in many respects. SAMUEL CALVIN.