

STRATIGRAPHY—TRADITIONAL AND MODERN CONCEPTS

TARAS P. STOREY¹ and J. R. PATTERSON²

ABSTRACT. Traditional stratigraphic units consist of one or more contemporaneous lithologic and faunal facies within a specific layer of rock. Each layer is local and regional in extent, and is separated from other layers by real time-significant boundaries which are either planes of contemporaneity or planes of unconformity. Where the boundaries are indistinct, faunas characteristic of the specific layer, and the stratigraphic succession in general, are used to identify the stratigraphic unit. Because of its regional attributes the stratigraphic unit serves as a correlation unit, as well as being the basic unit for local and regional stratigraphic subdivision and terminology. Zone, stage, series and system are such units which informally may be termed *stratigraphic formations* having regional time-significance.

Accusation by supporters of the American Stratigraphic Commission that geologists fail "to exclude concepts of time from consideration of the objective data on which alone properly defined rock units are differentiated", is not applicable to concepts of traditional stratigraphy. This accusation applies only to modern concepts of Litho-, Bio-, and Chrono-stratigraphy, which, while erroneously considered to be stratigraphic, more correctly are regarded as pre-stratigraphic procedures and concepts. Modern stratigraphic terms do not correspond with traditional concepts because Litho- and Bio-stratigraphy do not discriminate between distinct stratal superposition and different transgressive lithologic facies, or between stratigraphic paleontology and facies fossils. This failure has led to misconceptions in Chrono-stratigraphy and to development of unrealistic and inadequate terms, as well as to misapplication of traditional terms. Consequently modern concepts and terms are arbitrary and of questionable utility except in pre-stratigraphic procedures.

INTRODUCTION

Theoretical descriptions and general terminology for explaining everyday stratigraphic procedures and criteria fail to correspond with the practical and often reasonable results achieved in stratigraphic studies. This is because the practicing stratigrapher is unfamiliar either with the simple, basic language of stratigraphy or with the real distinction that exists between time-significant criteria and facies criteria. As a result modern stratigraphers have broadened specific meanings and restricted very general meanings of concepts and terms to such an extent that it is impossible to communicate satisfactorily on stratigraphic matters.

Although modern and traditional terms are alike, their intended meanings often are quite unlike. This is the reason why traditional and modern concepts appear incompatible.

It is chiefly because of this confusion, that the co-authors of this paper undertook a penetrating study of traditional and modern concepts. The critical reviews and comments of this paper are the result of sincere judgments which, it is hoped, will be taken as sincerely as they are given.

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¹ Canadian Husky Oil and Refining Limited, Calgary, Alberta.

² Amerada Petroleum Corporation, Calgary, Alberta.

Names and Correlations Committee of the Alberta Society of Petroleum Geologists.

TRADITION IN STRATIGRAPHY

Goethe has said, "That which our heritage has lent us has to be earned anew in order to possess it". In our case, the stratigraphic heritage is founded on the studies of William Smith. That Smith discovered the meaning of stratigraphy should not, however, be accepted *ipso facto*. Tradition does not necessarily justify a definition of stratigraphy any more than does utility. It is the common sense and the reality on which this tradition itself is based that makes Smith's heritage so valuable to us.

"Strata" Smith, as he was appropriately known to his acquaintances, observed in area after area that an orderly superposition of strata prevailed. He further noted that a particular interval of rock could be readily recognized as distinct from those above and below on the basis of the contained fossils even where this interval was of different lithological composition laterally. Although Smith was the first to demonstrate clearly these features, his real genius lay in their application as criteria of the otherwise not easily demonstrable lateral continuity or equivalency of strata, that is, correlation. This has been excellently and simply stated by Lowman (1949, p. 151): ". . . stratigraphic correlation can be stated in terms of stratigraphic fact—namely, stratal or faunal continuity". In following this procedure Smith was able to show in his table of 1799 the absence of certain Jurassic beds below the sub-Cretaceous unconformity because of his knowledge of their existence elsewhere (Arkell, 1933, p. 5-6). Thus, from a brief review of Smith's contribution to stratigraphy we can conclude without ambiguity that the original intention of the meaning of the term stratigraphy coincides with its etymology (strati-*strata* or rock-layers; graphy-*graphos*, something written or drawn). It was clear to Smith that strata are objective observable time-significant features which continue universally irrespective of lateral lithologic changes within them (intra-stratal) except where they are absent through erosion or non-deposition (fig. 1).

The criteria and principles of stratigraphy so firmly demonstrated by William Smith were primarily responsible for the great surge in stratigraphic research of the 19th century. A further step was the logical development of a nomenclature which served the three purposes of terminology, classification and correlation. In this field d'Orbigny was pre-eminent. Significantly, he continued to follow closely in the tradition of Smith. An exception to this tradition was his rather limited use of lithology as a criterion for correlation, which to some extent, is understandable because of the excellence of the fossil record. His philosophy is expressed in a translation of a sentence from his work of 1852 (Muller and Schenck, 1943, p. 267).

We have followed these horizons without having regard for the mineralogic composition and we have seen all the difficulties disappear by application of the two criteria of stratigraphic demarcation of stages: superposition and the limits of the faunas in the strata.

D'Orbigny's basic units of stratigraphy were the stage and the zone. His stages, based on local stratigraphy and named after a geographic locality, were utilized for the three purposes of terminology, classification and correlation.

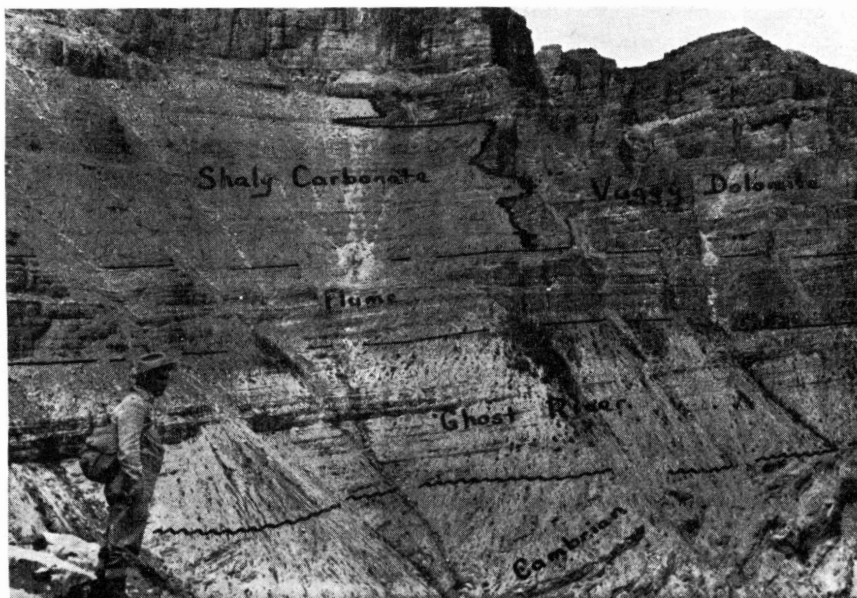


Fig. 1. End Mountain, Front Range, Canadian Rockies, west of Calgary illustrating:
 (a) The *continuity of strata* in the Upper Devonian irrespective of the change in lithology from vuggy dolomite on the right to shaly carbonate on the left of the heavy transgressing line.
 (b) The depositional absence of the greater part of the Middle and all of the Lower Devonian strata known elsewhere in the subsurface.
 (c) The termination of Middle Cambrian strata at the sub-Devonian unconformity.

The name of a stage, therefore, was available for universal application wherever strata of that same stage were known to occur.

D'Orbigny's stratigraphic zone is more familiar from its adoption and refinement by Oppel as a subdivision of a stage. A zone was named by both d'Orbigny and Oppel after a guide fossil, which has commonly led to the misunderstanding that a zone is something radically different from a stage. The difference, however, is only in degree, not in kind, for as Oppel himself says, zones could equally well have been named after places (Arkell, 1933, p. 17). As with a stage, the recognition of a stratigraphic zone is dependent on the presence of some evolutionary or otherwise diagnostic criterion of more than local occurrence be it faunal, depositional or both.

A stage is commonly and incorrectly held to be a paleontological unit because it is recognized universally by fossil criteria. This view is not complete, however, as it omits to indicate that the paleontological unit varies in stratigraphic (vertical) range in different places, and that the total range must be established by adding-up all of the different local ranges. Furthermore, owing to the natural discontinuous nature of facies criteria, certain non-fossiliferous strata which are contemporaneous with the faunal unit must also be included in order to recognize the presence of strata representing the stage in question. An illustration is Oppel's own recognition of a certain ammonite zone where it

is represented only by the occurrence of spongy limestones (Schindewolf, 1957, p. 397). Still other conformable strata above and below the faunal unit should be included (if reasonable) within the natural, distinct, stratigraphic unit (fig. 2).

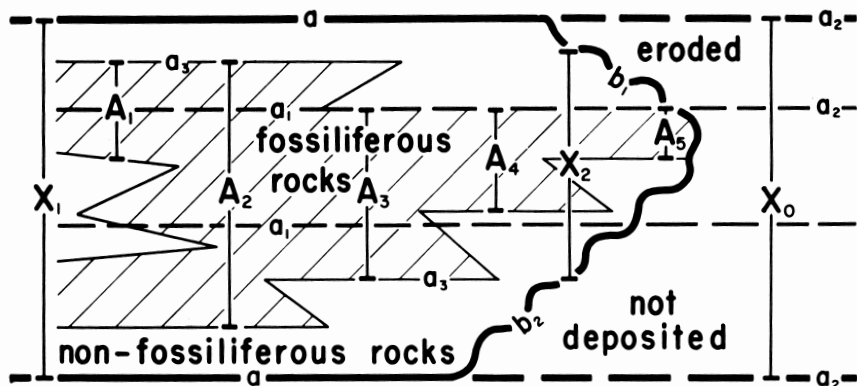


Fig. 2. Diagrammatic sketch of a "stage"—and various criteria which make up such a stratigraphic unit.

X_0 = hiatus representing complete stratigraphic unit X_1 .

X_2 = incomplete stratigraphic unit.

A_1, A_2, A_3 = different local ranges of guide fossil.

a, a_1 = inter-stratal planes of contemporaneity.

b_1, b_2 = inter-stratal time-significant unconformities.

a_2, a_3 = facies boundaries transgressing strata.

a_2 = hypothetical time-planes (of hiatus X_0) corresponding to inter-stratal planes a, a_1 .

Many geologists use the term stratigraphy in an extended sense, which from the etymological point of view is more correctly stratology (*strata* and *logos*—study of). An example is found in Gignoux's statement, "Stratigraphy, that is to say, the description of these successive panoramas, will then appear to them (professional geologists) as a harmonious succession of coherent geographies; it will then truly deserve the name of Science." (Gignoux, 1955, p. x).

The acceptance of this combination of objective stratigraphy and logic may perhaps be attributed to the concept of facies developed by Gressly (1814-1865). From his mapping in the Solothurn Jura, he concluded that different conditions of sedimentation must have been responsible for the observed differences in rocks and fossils which obviously were deposited simultaneously. Similarly and independently, but on theoretical bases, Prevost in 1838 explained that we should find in the stratal column contemporaneous deposits of terrestrial, littoral, marine, etc., origin replacing one another from place to place (see Zittel, 1895, p. 502-503; Teichert, 1958b, p. 2719-2721).

The facies concept has been responsible for a rather agnostic attitude among geologists as to the value of Smith's, d'Orbigny's and Oppel's fossil criteria in stratigraphic subdivision and correlation. Instead, it should serve to stress factors other than the fossil record which were taken into account by traditional stratigraphers in correlation. As Lapworth stated in counter to Barrande (Watts, 1939), "There are two valuable warnings with which the

future student of historical geology could ill afford to dispense. One is the fruit of paleontology without stratigraphy—the other of stratigraphy without paleontology”. The facies concept emphasizes the mutual relationship of paleontology and stratigraphy, and also serves to show that correlation is possible despite facies change. Johannes Walther enuniated such a feature of sedimentation as a principle in the correlation of facies (fig. 5) :

In a single sedimentary series, the variations of facies that are observed about a given point, reproduce in general the variations of facies (within) strata which follow vertically from the point. (adapted from Gignoux, 1955, p. 14)

The validity of Walther's law in correlation depends on the concept of facies variation (change). Both Gressly's and Prevost's conclusions were from considerations of place and time. It has been the practice to speak of contemporaneous facies as “facies changes” or as “facies of one another”, although stratigraphic facies, or stratigraphic equivalents, are terms which seem to be self-explanatory.

From the time of the Second International Geological Congress in 1881, traditional stratigraphic concepts have been universally accepted. This may be seen in the tables of stratigraphic classification of the Second and Eighth Congresses of 1881 and 1900, the tables of Schenck and Muller (1941), and Dunbar and Rodgers (1957, tables 15, 16, and 18, p. 291-292). These tables are based upon the principles that the relationship between rock and time is

<i>GEOLOGIC</i>		<i>STRATIGRAPHY</i>	
<i>TIME UNITS</i>		<i>FORMAL UNITS</i>	<i>informal units</i>
ERA	—	GROUP	stratigraphic formations OR correlation units
PERIOD	—	SYSTEM	
EPOCH	—	SERIES	
AGE	—	STAGE	
_____	—	<u>ZONE</u>	

Fig. 3. Chart showing traditional terms for Geological Time Units and Stratigraphic Units. Formal and informal stratigraphic units are of same kind, but the formal are internationally recognized while lack of sufficient evidence in places allows informal reference to such units as shown. Terms for contemporaneous facies or arbitrary facies are omitted.

stratigraphy, and the relationship between contemporaneous rocks is correlation (fig. 3). Thus, it has been traditionally accepted that the terms *stratigraphy* and *correlation* have time-significance.

PRACTICALITY OF TRADITIONAL STRATIGRAPHY

On the basis of this understanding the following traditional terms and their usages are favored by the authors because of their clarity and practical

applicability. These terms serve simultaneously the three purposes of stratigraphic classification, correlation and nomenclature. For example, the stratigraphic unit is classified as the basis for (1) systematic subdivision; (2) correlation through contemporaneity; (3) this unit may be informally termed "stratigraphic formation"—for detailed mapping.

(a) *Stratigraphy*.—This term has a very specific meaning in geology and therefore it is unsound to expand this meaning to apply to two or more categories of criteria. The term should not be applied to arbitrary facies criteria, nor to paleontological units which are only part of stratigraphic units. Nor should stratigraphy be applied to abstract time—except in a purely philosophic manner.

(b) *Correlation* in stratigraphy should always imply time-significance. It is the recognition of contemporaneity between different facies, either locally, regionally, or inter-regionally. This concept precludes correlation based upon lithologic similarity which more often than not is transgressive with respect to the stratal succession. If time-significance is not intended, then "lithologic comparison", or "tracing" of a particular lithology in outcrop, or in the subsurface are more correct expressions. Besides recognizing the stratigraphic unit as the basis for subdivision of a succession, it is possible to establish on purely physical criteria these basic intervals for regional correlation analogous with a stratigraphic zone or stage.

(c) *Stratigraphic unit*.—This term must be used when and where time-significance is intended. Confusion will be avoided if this term is not used for arbitrary facies criteria, which by themselves are not necessarily time-significant. The stratigraphic unit is not usually characterized by a typical lithology as generally is the American "formation", but rather is typified by its characteristic lithologic variations. On a regional scale, the unit can be recognized as the smallest, distinct interval within which contemporaneous facies (lithologic, faunal, environmental) can be correlated (figs. 2, 4, 5). Stratigraphic units are bounded by real, observable, time-significant horizons which are planes of contemporaneity or unconformity. Because the unit is not complete everywhere, it represents either all or only part of a certain interval of geologic time.

Where complete (fig. 4), the stratigraphic unit is bounded by horizons which approximate to planes of contemporaneity.³ Where the unit is absent, the consequent hiatus corresponds to the complete stratigraphic unit (not to a hypothetical time interval), and the upper and lower boundaries of the unit then coincide with the abstract time-planes representing the boundaries of the hiatus. Thus stratigraphic units are physical entities of rock which are more representative of certain intervals of time than are most other criteria. For example, paleontological units are useful in age determinations but these may or may not represent certain intervals of time as completely as do stratigraphic

³ Caster's (1934, fig. 2) diagram of terms for stratigraphic and facies criteria is very realistic and simple. It is, however, not adequate and may have been misleading in that the stratigraphic unit as illustrated, pertains only to where the unit is known to be most complete. Thus, the definition of time-stratigraphic unit is also inadequate, as it, as well as Caster's illustration, should take into account the same stratigraphic unit where it is not complete, (fig. 4) and is bounded by unconformities.

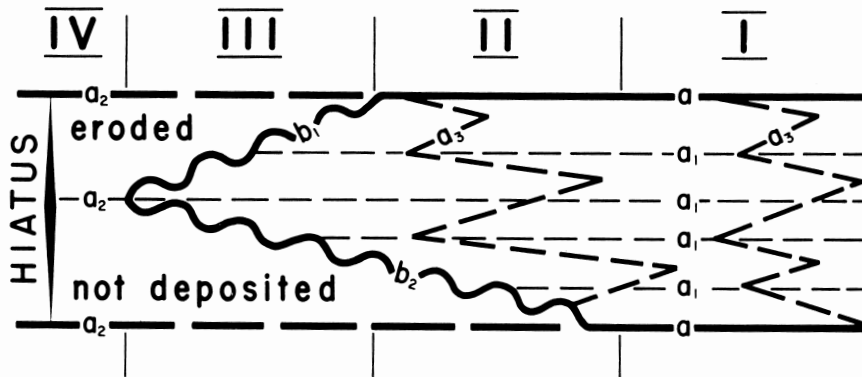


Fig. 4. Stratigraphic or correlation unit under different circumstances:
 I = complete stratigraphic unit where bounded by planes of contemporaneity;
 II = incomplete stratigraphic unit with two different boundaries;
 III = incomplete stratigraphic unit bounded by two unconformities. See Fig. 2 for meanings of letters.

units. Paleontological units therefore, must not be termed stratigraphic units and should not be confused with these. A stage is a stratigraphic unit and not a paleontological unit.

Although all stratigraphic units are analogous in kind, they are of different rank. It is useful to discriminate between the internationally recognized or formally established and named units, system, series, stage, and zone, and the informal stratigraphic units encountered everyday and whose relationships to the formal units are unknown (figs. 4 and 5). To illustrate our concept in practice, the Nisku formation of Alberta is Upper Devonian in age, but because it is not known which specific zone(s) or which part of the Frasnian stage it may represent, it is not practical to call it a stage or a zone, but the Nisku stratigraphic unit, or more briefly, the Nisku formation.

(d) *Stratigraphic horizons* (figs. 2, 4 and 5) are time-significant boundaries of distinct intervals in the stratigraphic succession. These boundaries may be sedimentary—approximating planes of contemporaneous deposition (Caster, 1934, fig. 2) or they may mark erosional or non-depositional surfaces of unconformity at varied angles to the bedding. The term stratigraphic boundary or time-marker is thus applied strictly to markers between strata and not to transgressive facies (formational) boundaries which occur within or across strata. *Planes of Contemporaneity* are lithologic marker-horizons which may have local or regional distribution. Generally they are sub-parallel to one another and parallel to local and regional bedding planes. They are caused by regional tectonic influences which produced relatively short-lived contemporaneous deposition, erosion or non-sequence, e.g., the marker horizons of Porter and Fuller (1959). Regionally, therefore, these are real, practical time-markers (as opposed to time-planes). Along the margins of sedimentary basins, where erosion and non-deposition were more effective, the planes of contemporaneity may develop into unconformities related to hiatuses corresponding to several tens or several hundreds of feet of stratigraphic section known where the suc-

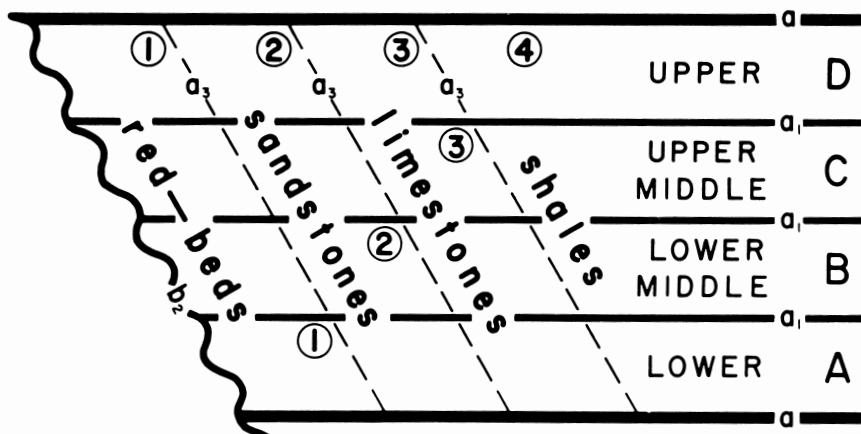


Fig. 5. An illustration of Stratigraphic Subdivision and Nomenclature. Also, shows Walther's Law of Correlation of Facies in its simplest form.

A, B, C, D: Stratigraphic units demonstrating superposition; each unit may be termed a stratigraphic formation, or A+B+C+D may be termed one stratigraphic formation with four vertical subdivisions, each with time-significant boundaries.

1, 2, 3, 4: Different stratigraphic (contemporaneous) facies which may be termed different lithologic members of each stratigraphic formation.

a, a₁, b₂: See figure 2.

cession is more complete. Thus, unconformities are also time-significant stratigraphic boundaries, but they are not planes of contemporaneity. A stratigraphic unit may be bounded by a combination of such various stratigraphic horizons (fig. 4).

The regional extent of these time-significant stratigraphic boundaries makes them often more valuable in regional correlation than are fossils or lithologies which invariably are less widespread. These latter criteria must be related to the stratigraphic boundaries as long as these persist, but when these are indistinct, fossils are useful to identify the specific stratigraphic unit.

(e) *Facies*.—Qualifying adjectives or manner of expression are applied to this general term for specific usage. “Stratigraphic facies units” means different contemporaneous facies, or different facies which are stratigraphic equivalents. The alternate traditional expressions “facies change” and “facies of one another” also have this specific connotation by virtue of the original derivation of the facies concept from the mapping of stratigraphic units.

(f) *Formation*.—This term has a broad meaning. When the term is used without an accompanying qualifying adjective it is invariably arbitrarily and naively applied, thereby creating ambiguity in understanding. Woodring's (1953, p. 1082) remark that “there should be no argument as to what a formation fundamentally is” is insignificant if he does not indicate whether his is a stratigraphic formation or a facies formation. Both of these are based strictly on real, objective, lithologic criteria. The former, however, is based on time-significant lithologic features which do not transgress stratal boundaries. The facies formation may be a facies of one, or of several stratigraphic units, and

need not be considered incompatible with time-significant criteria. In fact, the unsystematic proliferation of facies formational names can be controlled quite reasonably by naming only the specific stratigraphic unit as a formation which incorporates the facies units as members, tongues, reefs, etc., designated according to lithologic type, e.g., Nisku dolomite versus Nisku shale.

(g) *Zone*.—In stratigraphy this term has a very specific meaning which need not be confused with hospital zones or mineralized zones, and other such zones. A zone is not a paleontological unit but its recognition universally is based on its characteristic fossils—as is recognition of a stage. A zone is no different in category from stage, series and system; the only difference is in hierarchal rank. Why should a zone differ from the other three ranks of stratigraphic units when these latter consist of zones? A zone, stage, series, system and group are not paleontologic units and should not be confused with geological time units. The latter are bounded arbitrarily by abstract time-planes which should not be confused with real stratigraphic boundaries.

IMPRACTICALITY OF MODERN STRATIGRAPHY

The following modern terms are not recommended because their meanings in practice do not coincide with their definitions nor with their euphonic implications. These terms in theory place superfluous stress upon the means for determining conclusions, whereas, in practice, these means are actually the conclusions themselves. The plausibility, simplicity and utility claimed by proponents of modern terms fail to hold when driven to logical conclusions because they are based on fundamental distortions of the truth.

(a) *Litho-stratigraphy, rock-stratigraphy, or rock-units*.—These terms are supposed to imply that the stratigraphic study and conclusions arrived at are based solely on lithologic criteria believed to be dominantly objective; that is, without time-attributes or fossil evidence which are considered to be interpretive or dominantly subjective. This intended meaning is fallacious and correctly reflects a pre-mature or pre-stratigraphic understanding of the use and significance of these criteria, but there is no need to becloud the situation further by using the term *stratigraphic* when it is uncertain which criteria are in fact stratigraphic and which are only facies. It follows, therefore, that neither the term *rock-stratigraphic* nor its definition are realistic or adequate, and consequently its utility is seriously questioned.

The Illinois State Survey has used the term *rock-stratigraphic* in the time-significant sense. This use, and the term, are not favored because of its common misuse in the facies sense which has assisted in the loss of the perfectly sound and adequate term stratigraphic unit or stratigraphic formation for time-significant criteria.

(b) *Bio-stratigraphy*.—This term as generally employed is supposed to suggest that the stratigraphic studies and conclusions arrived at are based solely on fossil criteria which previously were considered to be dominantly subjective. In general practice, however, bio-stratigraphy covers both guide and facies faunas without recognizing that these are distinctly different but mutually useful types of criteria. Another misconception attached to bio-stratigraphic units is the belief that these are synonymous with so-called time-stratigraphic

units and therefore, the boundaries of both kinds of units are planes of contemporaneity. This misconception was illustrated at Dallas in March, 1959, when Wilson of Texas University concluded that the top of his time-stratigraphic Arikareean stage did not coincide with the plane which represented the top of his migrating evolutionary *Merychippus* bio-stratigraphic unit. Thus, it is evident that bio- and time-stratigraphic units and their boundaries need not be considered synonymous as suggested by Jeletzky (1956, p. 699), whose remarks probably would apply to the sum-total of faunal and stratigraphic criteria on a global basis which should be one of our ultimate goals for convincing others that some global standards are practical.

If the term bio-stratigraphy is to be used at all, it should be regarded as stratigraphic paleontology which is quite distinct from facies paleontology or bio-facies.

(c) *Time-stratigraphy*.—This term as usually employed is intended to imply that stratigraphic studies and conclusions reached are based exclusively on time criteria which are considered to be dominantly subjective in character. This term is applied by followers of the American Stratigraphic Commission, to simply stratigraphic units of the Second International Geological Congress of 1881. In theory however, Sloss, et al. (1949), Hedberg (1958), Wheeler (1958a), and others conceive of group, system, series, stage and zone units as having boundaries which are planes of contemporaneity only, and have concluded that these boundaries are parallel to, and coincident with the abstract time-planes of the theoretical Geological Time units. Because these workers have not been able to demonstrate this misconception in practice, having failed to appreciate that there really are objective time-attributes in the rocks, they have erroneously considered their time-stratigraphic units as subjective. This basic premise of these authors is, therefore, quite unrealistic and inadequate, and the prefix "time" is superfluous because it places undue emphasis upon time-attributes in the rocks where their presence in fact has not been appreciated by these workers. Because the basic premises in time-stratigraphy are not correct, the related concepts are consequently ambiguous and of little practical value in stratigraphy proper.

TRADITIONAL AND MODERN CONCEPTS COMPARED

The basic difference between traditional and modern stratigraphic concepts is that the former recognize in stratigraphy a "harmonious succession of coherent geographies" (Gignoux, 1955) whereas the latter consider stratigraphy as an "arbitrary partitioning into arbitrary units" (Hedberg, 1958b, p. 193). Many reasons produce these different attitudes toward stratigraphy. The main reason, however, is that traditional procedure is based on thorough studies which have led to proved and systematic conclusions whereas modern procedures are often derived from reconnaissance work. It follows from this arbitrariness that modern schemes for classifying and naming stratigraphic criteria are unsystematic and ambiguous. To make matters worse the ambiguity has been increased by the indiscriminate use of traditional terms for example, *stratigraphy* for time-significant criteria and for facies criteria with no time-significance. It is because of the arbitrary attitude of modern stratigraphers

that the stratigraphic language has become so ambiguous. Indeed, the traditional stratigrapher has become almost as ambiguous and indiscriminate as his modern counterpart by acceding to the use of modern terms and definitions because of a naive reluctance to openly disagree with modern concepts. We therefore, do not agree with the claim that modern concepts provide a systematic code for all stratigraphic purposes. We agree with Schindewolf (1957) that modern concepts and procedures are very essential but they are in reality pre-stratigraphic.

An example of traditional concepts of stratigraphic criteria and their relationships may be seen in the illustrations by Muller and Schenck (1943, figs. 6 and 7, p. 272-274). By contrast, modern concepts of the same criteria are illustrated by Hedberg (1958, fig. 2, p. 205), and Wheeler and Mallory (1956, figs. 4 and 6, p. 2715), and Wheeler (1958, figs. 2 and 4, p. 1052-1053). It is to be noted in particular that Muller and Schenck stress firstly the time-factor (i.e. stratigraphic units and their boundaries); secondly, the pertinent fossil criteria, and lastly, if at all, the lithofacies criteria (fig. 4). The other authors, however, arbitrarily stress the relative importance of these different criteria in reverse order, thus illustrating further the difference between traditional and modern concepts. Whereas the traditional stratigrapher sets his sights high by regarding attributes of time as the guiding factor in stratigraphy, modern workers drift aimlessly about in their arbitrary philosophy that lithologic, biologic and time criteria should be treated without simultaneously relating one with the other.

The confusion which has resulted from the ambiguity in modern stratigraphic language may be illustrated first by "rock-stratigraphic". It is generally agreed that in subdividing a local geological section it is necessary to use objective rock-units and their boundaries. In practice, however, there are found three distinctly different categories of objective rock criteria: (1) planes of contemporaneity, (2) planes of unconformity, and (3) litho-facies boundaries, yet, all of these are termed "rock-stratigraphic" (figs. 2, 4 and 5). It is, therefore erroneous and certainly misleading to imply that these time-significant or stratigraphic criteria are "rock-stratigraphic", which is a rather unfortunate way for the Illinois Survey to 'agree' with the Stratigraphic Commission.

Modern usage of the term rock-stratigraphic is misleading because its etymology and euphony suggest that, in the traditional sense, it is simply synonymous with stratigraphic, or according to modern vernacular, with time-stratigraphic. Modern stratigraphers (Schenck and Muller, 1941), began misusing the term stratigraphic when they misapplied it to litho-facies criteria and incorporated it into their 'code' for their own usage. The 'official' approval given this ambiguous usage by the Stratigraphic Commission has left the traditional stratigrapher with neither the term itself, nor with the original definition for, simply—stratigraphic criteria. The unavailability of the term rock-stratigraphic for stratigraphic criteria has led Forgotson (1957, p. 2108) to the shrewd and realistic observation that

The work of stratigraphers making regional correlations and mapping rock units on a regional scale is hindered by the lack of a suitable terminology. The relation-

ships of the vertically segregated rock units in one area to equivalent units in areas where the lithologic character is different, can not be adequately expressed by the present system of stratigraphic nomenclature.

However, Forgotson's proposal of the term *format* and the Illinois State Survey's recapture of rock-stratigraphic for its more realistic use, do not fully solve the problem. These workers fail to realize that the lack of a suitable term must be attributed to modern stratigraphers who have claimed the term for their own system of stratigraphic nomenclature wherein the originally suitable term has been rendered unsuitable. It is useless to propose new terms when former terms for the same criteria are presently being misused for other criteria.

Bio-stratigraphic correlation has been considered to be subjective⁴ because it is useful in establishing time-stratigraphic boundaries which are also condemned as subjective. Jeletzky (1956, p. 688), in rightly criticizing this view, states:

In this connection, it is proposed that the unfortunate and misleading term, bio-stratigraphy be dropped altogether. Under the definition of stratigraphy proposed in this paper, this term becomes highly misleading and practically synonymous with 'bio-facies'.

Thus Hedberg's claim that one term should not be used for several purposes is a paradox upon modern usage of the terms litho-stratigraphy and bio-stratigraphy.

The insistence that stratigraphers should abide by the arbitrary rules and ambiguous terms and definitions of modern concepts is unfortunate, and the fallacy of such unrealistic procedure is demonstrated by innumerable examples similar to the following from Harker, Hutchinson and McLaren (1954):

Sloss and Laird (1947, p. 1427) report that conodonts from their Unit C of the Devonian in northwestern Montana were considered of Late Devonian (Senecan) age by C. L. Cooper (1946, p. 612). On lithologic grounds they believed that unit to be in part a correlative of the Ghost River of Alberta. Webb (1950-51, p. 2299) regarded this formation as the lithologic equivalent of the sub-surface Elk Point of which the upper part at least is Middle Devonian. Andrichuk (1951) brings forth cogent evidence based on lithology, in support of this correlation.

Here, it is quite apparent that "lithologic similarity" is the dominantly objective factor in the otherwise impossible correlation of Upper Devonian with Middle Devonian strata.

In addition to the unrealistic concept of 'correlation' based on lithologic similarity, there is a strong tendency for stratigraphers and paleontologists to sanction another form of impossible correlation. This is the practice of including an unconformity within a formation as it is generally understood (Woodring, 1953, p. 1082). This procedure neglects the fact that an unconformity may mark a break in the continuity of the stratigraphic record which is much more important than the fact that there may be lithologic similarity above and below the unconformity. The damaging aspect of this procedure is that on the basis of one guide fossil below an unconformity an entire formation all too often has been assigned to one stage (fig. 6). Consequently strata separated by the unconformity are considered to be equivalent in age whereas

⁴ It is not known whether the strong arguments of Jeletzky and others have brought about a reversal of opinion, or whether Hedberg (1958, p. 195) and others are actually convinced, but bio-stratigraphy is now considered dominantly objective.

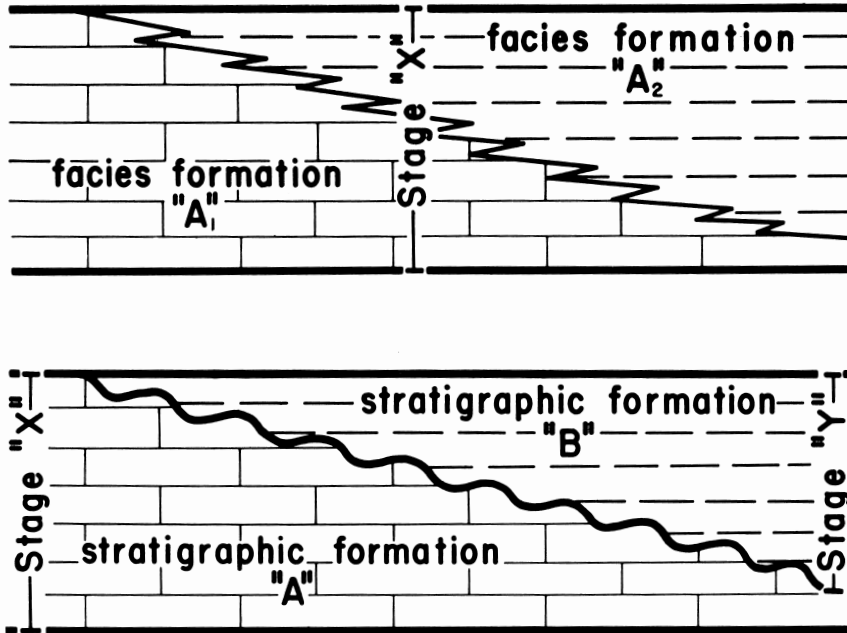


Fig. 6. Diagrams to show that in bio- and litho-stratigraphy which do not discriminate between arbitrary facies and time-significant criteria, unconformities and other stratigraphic horizons (lower diagram) are often wrongly depicted as facies boundaries (upper diagram) with resultant misconceptions in correlation (chrono-stratigraphy) in upper diagram. Upper diagram represents an example of pre-stratigraphic conclusions frequently derived from modern concepts, and true stratigraphic conclusions in lower diagram. Hence this figure illustrates the uselessness of controversy between modern and traditional concepts in stratigraphy.

in fact their deposition may have been separated by many epochs or even periods in time. It is serious violation of stratigraphic principles, to consider that a regional unconformity occurs within a stage. It is argued, therefore, that any effort to mask an unconformity is considered unrealistic in matters of correlation.

The importance attached by modern workers to lithologic similarity has led to considerable ambiguity in modern schemes for nomenclature of stratigraphic units such as group, formation, member, etc. The application of these names to a particular rank admittedly is a matter of personal, arbitrary choice. Thus, modern schemes for ranking and naming these units are not systematic, nor should they be expected to be so in view of the fact that modern workers do not attempt to refer transgressive litho-facies criteria to specific and consistent inter-stratal features. Another characteristic which erroneously is believed to be attributed to a formation only is its mappability. Actually this part of the definition is also unrealistic because discrete stratigraphic units (format of Forgotson), whether they consist of one or more contemporaneous lithologies, are also lithologic and often better suited for most mapping purposes because of their greater areal distribution. Thus the phrase, "a formation is a mappable unit" can not be logically considered applicable only to a lithofacies

unit, as it is equally and probably more realistically applicable to stratigraphic units.

At the expense of denying the traditional stratigrapher the right to map objective, observable stratigraphic units, Hedberg (1958, p. 203-204), in presenting arguments for modern concepts, states:

Just because the age is the same is no reason for uniting totally different lithologies under the same formation name The geologic map picture is not complete without showing both the arrangement of rocks with respect to lithology and the arrangement of rocks with respect to time of origin, but it is impossible to do both with the same units.

These statements can hardly be considered useful arguments based as they are on the false premise that observable facies lithologies are more objective than observable lithologic evidence for superposition and contemporaneity which modernists disdainfully call subjective or interpretive. It is precisely this false premise of subjectivity and consequent misconceptions of stratigraphic classification, and indiscriminate terminology, that has caused the appalling confusion in stratigraphy. There is absolutely nothing wrong with showing both the different lithologies and their containing stratigraphic units simultaneously by using simply one name for the stratigraphic unit, e.g. Nisku, and another name for the lithologic facies, e.g. shale. Geologists who have not been aware of this impossibility have been doing just this thing for over 150 years. For example, Cobban's (1945) and Imlay's (1952) Jurassic formations of Montana, Wyoming, North and South Dakota, and the Devonian formations of Alberta as proposed by Imperial Oil's geological staff (1950) are such stratigraphic formations.

The time-worn song that "a formation is a rock-stratigraphic unit" is ambiguous. Both terms are unrealistic and indiscriminate because their meanings are too general without specific qualification. The dangerous part of such usage is that it denies the greater usefulness of true stratigraphic units. The authors, therefore, refuse to accept the remarks in Report 5 (p. 1886) that, "The term zone is not a time-stratigraphic term. It is not a subdivision of a stage". The sponsors of such concepts obviously are not thinking stratigraphically, but rather in a manner akin to arbitrary zonation into arbitrary lithofacies units. If these sponsors are not aware of the real distinction between stratigraphic paleontology and facies paleontology, they obviously cannot appreciate that guide fossils provide criteria for the basis of the stratigraphic zone. We agree with R. C. Moore's commentary on Report 5 (p. 1888) where he states that, "The most cursory acquaintance with published literature demonstrates that the position of our Commission in this matter [of zones] is utterly unrealistic. Accordingly, I must vote as emphatically as possible against it".

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