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# Guidelines for using stratigraphic nomenclature: Lithostratigraphy and chronostratigraphy

## 1. Lithostratigraphy

### 1.1 Definition

Lithostratigraphy classifies a succession of rocks into distinguishable lithological units, both vertically and horizontally, and regardless of their age. In order to define a lithostratigraphic unit, all observable rock characteristics and boundaries seen in the field should be used. A lithostratigraphic unit may be sedimentary, magmatic, metamorphic or composite (for example volcanosedimentary). The goal of lithostratigraphy is to provide an objective framework for further geological investigations.

### 1.2 Lithostratigraphic Classification

#### 1.2.1 Formal units

1.2.1.1 In agreement with the International Stratigraphic Guide (Salvador 1994) and the German-Austrian recommendations (Steininger & Piller 1999), the hierarchy of the units is as follows:

Super Group	Supergruppe	Super-Groupe	Super-Gruppo
Group	Gruppe	Groupe	Gruppo
Formation	Formation	Formation	Formazione
Member	Member	Membre	Membro

Super Group      Supergruppe      Super-Groupe      Super-Gruppo  
Group              Gruppe              Groupe              Gruppo  
Formation              Formation              Formation              Formazione  
Member              Member              Membre              Membro  
Bed              Bank              Banc              Strato

The name of a lithostratigraphic unit consists of two parts: a geographical term, resulting from its type section or type area (cf. 1.2.2.3) is followed by a hierachic term (e.g. Reuchenette Formation). The terms "Formation" and "Member" can be replaced by that of the prevalent rock-type, for example the "Marnes bleues d'Hauterive".

Before creating new formations it is important to carefully check if traditional names, which were introduced before the publication of the International Stratigraphic Guide, can be adapted to the scheme recommended here (see Fig. 1).

The lithostratigraphic nomenclature can also be applied to deposits of the last ice-age. Special issues with these units are addressed in chapter 1.2.4.

It is necessary to point out that new units should only be defined if this fulfils a need. Prior to the definition or renaming of units the SCS and the Swiss Geological Survey (Geological Mapping section) should be consulted. These organisations can refuse new names in justified cases. In descriptions (lists of synomyms) and on geological maps, traditional but obsolete names can be listed next to the correct terms (e.g. Bommerstein Formation – "Eisensandstein").

1.2.1.2 In lithostratigraphy, the *formation* represents the fundamental unit. A formation is a rock unit whose lithological characteristics differ from surrounding formations and/or which is bounded by mappable discontinuities. If the rock is made up of a significant quantity of fossils, this may also be added to its lithological characteristics. In mapping, geomorphological criteria can be taken into account. There are no strict rules to determine the minimal thickness of a formation. Mappability at a scale of 1 : 25 000 is the limiting criterion. However, if a formation can only be recognized in its type section (e.g. quarry, street outcrop), it must keep the ruling of an informal unit even if its type section is clearly defined (cf. 1.2.3). A temporary outcrop should not be selected as a type section of a lithostratigraphic unit.

1.2.1.3 Several formations can be joined together within a *group*. Definitions of groups must conform to the same rules as

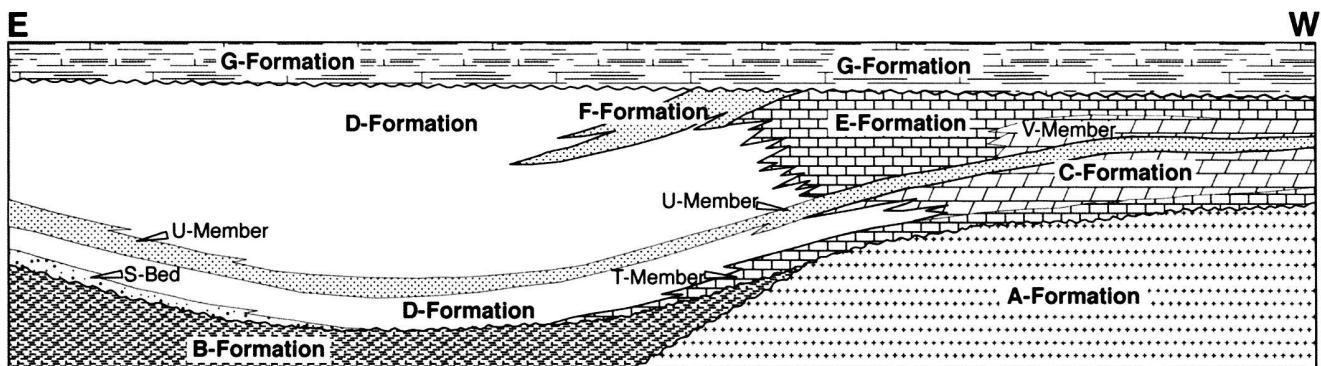


Fig.1. Possible relations between lithostratigraphic units. The T-Member forms part of the C-Formation. The S-Bed and the U-Member form part of the D-Formation. Neither a "Lower D-Formation" nor an "Upper D-Formation" exists (see paragraph 1.2.2.1). The V-Member forms part of the E-Formation. The F-Formation contains neither members nor beds. The Formations C-F can be united into a group if required (modified after Salvador 1994).

those of the formation. If a group does not have a type section, it is defined by the formations of which it is comprised and their respective type sections. Several groups can constitute a *super-group*.

1.2.1.4 A formation can be subdivided into *members*. Their definition must conform to the same rules as those of the formation. It is not essential to fully divide a formation into members; one can identify these individually within the unit. In the same way a characteristic layer may be defined as a *bed*.

1.2.2 Procedure to be followed during the establishment of a formal lithostratigraphic unit

#### 1.2.2.1 Naming

A formation is called after the type locality (cf 1.2.2.3). The place name is added to the name of the unit (e.g. Reuchenette Formation). The name of the formation is given a capital letter. If the locality name is different according to the language (e.g. German, French, Italian, Rhaeto-Romanic), it is the name used locally which will be chosen. The hierarchical position as well as the origin of the name must be explained. The formation and its members, or its beds, should not bear the same place name (e.g. Reuchenette Formation, Reuchenette Limestone). Names which predetermine the position of the unit within the rock complex (e.g. basal Complex, Lower Oolite Member) should not be used.

#### 1.2.2.2 Description

During the definition or revision of a formation it is important to name the criteria which define top, bottom and lateral extent of the unit as well as its differences from the surrounding units. A detailed lithological description should be made (e.g. of lithology, colour, mineral contents, fossil content, etc.). The age of the unit as well as the dating methods used, should also be specified if possible. The boundaries, apart from the type section, can be corrected at a later date, if necessary.

#### 1.2.2.3 Type section

When defining a new formation, the type section must be chosen. If the boundaries of the type section are not clear, a reference (boundary stratotype section) must be defined and described in detail.

#### 1.2.2.4 Type area

In its type area, the lithostratigraphic unit needs to be typically developed, well exposed and easily accessible. The type area must be specified in the description of the unit, preferably with the numbers of the corresponding Swiss National Topographic Maps 1 : 25 000. Both the type section and the reference sections must be located in the type area. Information on the regional extent of the unit will also form part of the description.

#### 1.2.2.5 Priority

If several lithostratigraphic terms prove to be synonymous, the rule of priority will be applied, provided that this does not remove a firmly established and well defined term.

#### 1.2.2.6 Remarks

The terms "Series" or "Layer" should no longer be used to describe formal lithostratigraphic units. In the same way the term "Zone" does not form part of the lithostratigraphic nomenclature. In case of doubt it is recommended to use Salvador (1994; in particular chapter 5). The SCS and the Geological mapping section of the Swiss Geological Survey should also be consulted.

**Recommendation:** The type and the reference sections should, if possible, be placed under protection as geotopes.

#### 1.2.3 Informal units

1.2.3.1 The informal units will be identified as such in the database ([www.stratigraphie.ch](http://www.stratigraphie.ch)). They must be replaced by formal units or eliminated as soon as possible.

1.2.3.2 Well defined but incorrectly named units (with "Series", "Layer" or "Zone") should be renamed and be given an agreed hierarchical order. Their relationship to former names must be clearly indicated. If missing, a new type section needs to be established and lithologic criteria which define its limits should be provided (e.g. Couches de Villarvolard, Prodkamm Series).

The same holds for a certain number of older terms (e.g. Öhrli limestone, Taveyannaz sandstone).

Old and well established denominations often use the name of a fossil (e.g. Couches à Mytilus, Opalinus-Ton), or lithological characteristics (Couches rouges, Hauptrogenstein) instead of a place name. It is difficult to abolish such denominations and in many cases it is not necessary in particular for the lithological terms. Nevertheless we recommend to give such denominations the formal status of a formation (or member) by providing a type section or a reference section which defines their characteristics and their limits. This helps to prevent that the same term is employed for different strata.

#### 1.2.4 Deposits of the glacial period\* and the Holocene

Deposits of the glacial period exhibit characteristics which distinguish them from all other rock formations:

- They present a marked diversity and display a variety of facies over short distances. Often the identifiable units are only present in the immediate neighbourhood of the type-locality.
- They are always closely related to the relief of their subsurface (bedrock or drift), so that their geographical localization and their geomorphological position (e.g. altitude) are significant and distinctive characteristics.

\*Here we use the term "glacial period" instead of "Quaternary", because Pliocene (Tertiary) glacial deposits also exist in Switzerland.

In spite of these characteristics, the deposits of the glacial period can and must be treated according to general rules of the lithostratigraphy (cf. 1.2.2). The name of a lithological unit is composed of the name of a locality and the term “Formation” or “Member” (e.g. Ecoteaux Formation). Where the lithological composition is obvious, one can also use the lithology for characterizing the sedimentary body concerned (e.g. Rafzerfeld Gravels).

To take account of their particular nature, great importance should be given to bounding discontinuities when defining lithostratigraphic units. These bounding discontinuities can be for example: a surface covering of the rock substratum; an erosional unconformity; a paleosoil or a topographic surface (in particular its form). A topographic surface also makes it possible to take account of the geographical and geomorphological aspects.

The lithostratigraphic procedure should be used only for accumulations whose formation is completed. Active landforms, such as alluvial cones, modern fluvial deposits or landslides are not subject of a stratigraphic denomination.

## 2. Chronostratigraphy

### 2.1 Definition

Chronostratigraphy is concerned with the dating of rocks of the Earth's crust, based on a variety of methods.

Two fundamentally different concepts need to be discussed:

#### 2.1.1 Dating of rocks,

either in years (for the most part in millions of years: My/Ma), i.e. *numerical age*, or in *relative age*, according to a chronological reference scale (cf. 2.2.1.3).

#### 2.1.2 Temporal correlations

This involves the lateral correlation of reference horizons considered as isochrones (chronohorizons). For example, event stratigraphy enters into this category. Thus, the datings provided for a given locality can be applied in a more or less precise and sure way to non-datable layers at another locality. The temporal correlation can thus clarify the chronological relationships in a sedimentary basin when no dating is possible. The accuracy and the precision of temporal correlations play a crucial role for the definition of the limits (“Golden Spikes”) of the units of the standard geochronological scale, i.e. in the choice of the boundary stratotypes (GSSP = Global Boundary Stratotype Section and Point) (Cowie et al. 1986, Remane et al. 1996, International Commission on Stratigraphy 2002a, Remane 2003).

### 2.2 Geochronological classification of relative ages

#### 2.2.1 The international geochronologic scale standard

2.2.1.1 The traditional classification, based on the current *standard geochronological scale* (International Commission on Stratigraphy 2002b), was developed during the 19<sup>th</sup> century. A formal hierarchy was proposed for the first time at the International Geological Congress (IGC) of Bologna in 1881, and was established in detail in the reports of the 10<sup>th</sup> IGC in Paris (International Commission of Stratigraphic Classification 1900). It is important to note that often a distinction is made between the material “stratigraphic” units and the non-material “chronological” units, which are temporally equivalent, whereby both have the same name.

2.2.1.2 The principle of two parallel scales, material and immaterial (chronostratigraphic units vs. geochronologic units), was adopted in International Stratigraphic Guide (ISG: Hedberg 1976: p. 67, Salvador 1994: p. 77f.) and has been generally used since then. This same principle was also integrated in the German-Austrian directives (Steininger & Piller 1999: p. 4).

According to the ISG, chronostratigraphic units gather rocks formed *during a certain period and surrounded by isochronous surfaces*. In the 2<sup>nd</sup> edition of the ISG, the definition is extended to *unlayered rocks* (Salvador 1994: p. 77), but the predetermined condition for the limits is nevertheless maintained (p. 78: “*Chronostratigraphic units are bounded by isochronous horizons*”). It is obvious that this part of the definition can neither be applied to intrusive bodies, nor to sedimentary sills and dykes which are commonly found, e.g. in the Lias of Arzo. None of these new recommendations considered that no material stratigraphic classification such as the current lithostratigraphy existed in the 19<sup>th</sup> century. This is perhaps the reason why distinctions between chronostratigraphic and geochronologic units are often arbitrary and contradictory in the literature.

2.2.1.3 Contrary to the ISG and the German-Austrian directives, we follow Zalasiewicz et al. (2004) and recommend that **material time units should no longer be used** and that only one time hierarchy (chronostratigraphy) should be maintained, with geochronological terms according to ISG. The only exception will be the smallest formal chronostratigraphical unit, the **stage**, in accordance with the recommendation of Zalasiewicz et al. (2004). This has the additional advantage of making the term “age” available for general use (Harland and al. 1990).

#### CHRONOSTRATIGRAPHY

Eon

Era

Period

Time

Stage

#### EXAMPLES

*Phanerozoic*

*Cenozoic*

*Neogene*

*Miocene*

*Aquitanian*

The **basic unit** is provided by the stage because finer subdivisions are not often applicable on a global scale.

2.2.1.4 The chronostratigraphic units can be subdivided in units with open nomenclature, for example Early Devonian, Mid (or Middle) Devonian, Late Devonian; early Aquitanian, late Aquitanian. The first letter of the adjective will be in capital letter in the case of internationally approved subdivisions, otherwise it will be in lower case.

2.2.1.5 The International Commission on Stratigraphy (2002b) established a *standard geochronological scale* according to the stratotype principle. This nomenclature should be used in figures and tables of any publication. Insofar as the chronostratigraphic limits are defined by a GSSP, they should also be used according to international convention. This does not prevent an author from expressing a different personal opinion regarding the position of the limits in the text, but the existence of an International Convention must always appear in the figures and the tables. Should the use of regional geochronological units be unavoidable, these have to be identified and, as far as possible, be linked with the standard international scale.

## 2.2.2 Reasons to discard material time units

2.2.2.1 As already mentioned, the requirement to limit chronostratigraphic units by isochronous surfaces cannot apply to intrusive bodies, sedimentary dykes and sedimentary sills. Their dating is not possible by chronological correlations.

2.2.2.2 As Walsh (2001) demonstrated, the interval of time attributed to a given geochronological unit is often not entirely represented by deposits. In such cases the material limits of the "chronostratigraphic" unit do not represent isochrones. Large gaps particularly occur in units at higher hierarchical levels. Hence the following question arises: What does the "Late Carboniferous of the Swiss Alps" or the "Triassic of the Swiss Jura" really mean?

2.2.2.3 When revising a date, the introduction of new names for old units may create unnecessary confusion. This can be avoided by working with a combination of lithostratigraphy and chronostratigraphy.

All these problems are discussed in detail by Zalasiewicz et al. (2004). The new French (Comité français de stratigraphie 1997, Odin et al. 2004) and English (Rawson et al. 2002) recommendations illustrate the different concepts.

## 2.3 Recommendation.

### The use of material age units is to be avoided.

The use of lithostratigraphic units (even informal ones), together with the information regarding the approximate

chronostratigraphical age provides the necessary information and removes uncertainty. Any later revision of the dating will not create confusion because the material object (lithostratigraphic unit) remains unchanged.

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