

# Chronostratigraphic terminology: Building on principles

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**ABSTRACT:** Relative time in earth history is linked to geometrical relationships—below means older, and above means younger—and is rooted in the three fundamental principles of horizontality, lateral continuity and superposition enunciated by Steno (1669). This relationship between spatial geometry and time is the reason for dual terminology in chronostratigraphy, with rock-units (Lower/Upper) determining time-units (Early/Late). Abandoning the former would sever chronostratigraphy from its roots, and lead to semantic confusion. Lower and Upper specify position, and apply only to the observed sedimentary record. Early and Late specify interpreted time, and denote not only relative age (i.e., time of deposition) but also time of subsequent diagenesis or alteration. Although each concept closely implies the other, they are not the same logically. Dual terminology should be retained.

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## INTRODUCTION

Historical Geology addresses four fundamental questions: What, When, How, and Why. The validity of the answers offered to the ultimate questions Why and How is entirely dependent on the accuracy of the timing (When?) between well established facts (the scientific What?). When? may be the most fundamental yet the most difficult question in earth science. It is not surprising that while a large body of geological facts had already been described by the late 19th century, the measure of geological time is still being debated.

Geological duration is expressed by different means, relative and numerical. Relative means concern the discipline of chronostratigraphy, in which the sedimentary strata themselves participate in a simple but exclusive system of reference that rests upon the duality between below/older and above/younger. Chronostratigraphy is applicable everywhere, and has been (at least in intent) the common, albeit specific, language of stratigraphy since the late 19th century. Numerical means are of several kinds, isotopic dating holding the leading role. Mostly restricted in applicability and based on complex mathematics, they formulate time in familiar terms, i.e., in years.

Relative and numerical time are rather disparate, and it is striking that whereas the below-above duo is inherent to chronostratigraphy, it is implied (isotopic dating) or (often) assumed (astrochronology) in non-chronostratigraphic methods. Chronostratigraphy focuses on order as the indisputable evidence of the passage of time; geochronology (the measurement of geological time) uses numbers to more accurately describe the passage of time that is established by chronostratigraphy. If this describes correctly the methodological approach used to extract time scales from the stratigraphic record since Steno (1669), it would seem legitimate that chronostratigraphic nomenclature be dualistic. This duality was first formally proposed by Schenck and Müller (1941) and has been accepted by most of the geological community (Hedberg 1976; Salvador 1994).

Where scientific inquiry is involved, advances in understanding relationships often result in thorough reconsideration of basic systems of classification and nomenclature, possibly causing complete upheaval (consider the current systematics of organ-

isms, which from two kingdoms until the late sixties has expanded to six to eight kingdoms since (Cavalier Smith 2004), and now may be in the process of abandoning the concept of kingdom itself [Adl et al. 2005]). It was thus predictable that the considerable advances in extracting time from rocks in recent years (e.g., Berggren et al. 1995; Gradstein et al. 2004 and references therein) would lead to a reconsideration of some fundamental aspects of geochronology. Indeed, the Stratigraphic Commission of the Geological Society of London (Zalasiewicz et al. 2004) has invited a debate on the usefulness of rock-time units in chronostratigraphy. I present here my thoughts on this essential subject.

## WHAT IS CHRONOSTRATIGRAPHY?

The term chronostratigraphy (Schenck and Müller 1941) is being used to express different concepts, including a succession of stratigraphic events in a section that serves to date it. Chronostratigraphy is taken here as a framework of reference for relative chronology (Hedberg 1976; Salvador 1994). It is a body of rocks that specifies a certain interval of time. The lower and upper boundaries of a chronostratigraphic unit define two precise moments of geological time. The span of time between these moments is called a geochronologic unit. (These definitions differ in form, not in intent, from those given in the International Stratigraphic Guide, as discussed separately, Aubry, this volume). Chronostratigraphy is based on the definition of (litho)stratigraphic horizons, referred to as boundary-stratotypes (Hedberg 1976; Salvador 1994) or Global Stratotype Standard-section and Points (GSSPs) (Cowie et al. 1996; Remane et al. 1996; Salvador and Murphy 2001). These set the limits of chronostratigraphic units, and, by inference, of geochronologic units. Chronostratigraphic units are organized in a hierarchical succession encompassing increasingly larger units (from stage to eonothem), from which a parallel succession of geochronologic units is deduced (from age to eon). For all the ambiguity that is associated with the GSSP concept (Aubry et al. 1999, 2003; Remane 2003), GSSPs are ultimately stratigraphic horizons that set the limits of geochronologic boundaries. Thus today as in the past, chronostratigraphy proceeds from rock to time (not from time to rock), the definition of geochronologic units being tied to that of chronostratigraphic units. In practice, ages, epochs, periods, eras and erathems are



FIGURE 1

The contemplation of stratigraphic panoramas as grandiose as the Grand Canyon, or as extended as in the Dababiya Quarry where the GSSP for the base of the Eocene is defined, is not the contemplation of time. For the initiated eye, strata may evoke time and a long history, but one observes strata and only strata. The rest is left to imagination. Sections are not measured in years but in meters with a jacob-staff. Field geologists do not map time, which is only one of the four dimensions required to thoroughly describe the stratigraphic record (Aubry 1995) at any selected (local, regional/asinal, global) scale. Photography by Christian Dupuis.

tied to stages, series, periods, erathems and eonothems, respectively. Further, temporal qualifiers such as *early* and *late* are tied to the stratigraphic qualifiers of *lower* and *upper*. This is pure logic, a rational reading of the principle of superposition. Accordingly, both chronostratigraphic and geochronologic units are currently formalized, and the dual chronostratigraphic nomenclature that was activated by Schenck and Müller (1941) is still operative.

#### THE GEOLOGICAL SOCIETY OF LONDON PROPOSAL

The Stratigraphic Commission of the Geological Society of London (Zalasiewicz et al. 2004; referred to below as SCGSL04) has invited comments from the international stratigraphic community on its suggestion that dual terminology in chronostratigraphy be abandoned to the sole benefit of geochronologic units. Its main points are to ease communication between scientists, editors and the public while simultaneously broadening the application of chronostratigraphy to all rocks, sedimentary and non-sedimentary alike. Its case rests on the introduction of GSSPs claimed to have made obsolete the distinction between chronostratigraphic and geochronologic units. The question is:

#### Does the acceptance of the concept of GSSP justify a change in chronostratigraphic practice?

As carefully written as they may be, legal documents are subject to interpretation and subsequent clarification. Does not the Bill of Rights clarify some aspects of the American Constitution? Scientific codes and guides are not exactly legal documents, but their role is to regulate practice for the benefit of national and international understanding. They too are subject to interpretation. A deep dissension has arisen in the reading of stratigraphic codes. It concerns which takes precedence in chronostratigraphy: Is a chronostratigraphic unit defined by the amount of time (=geochronologic unit) it represents? Or does a chronostratigraphic unit determine a geochronologic unit? This represents a major subject of contention with regard to the interpretation of the International Stratigraphic Guide (Hedberg 1976; Salvador 1994; see Aubry, this volume). Some authors (e.g., Harland 1978; 1992; Walsh 2001 2003) claim an opposite relationship between chronostratigraphic and geochronologic units, such that the extent of chronostratigraphic units is predicated on the extent of geochronologic units. This is also at the root of a related, but less acknowledged conflict with regard to the nature of GSSPs.



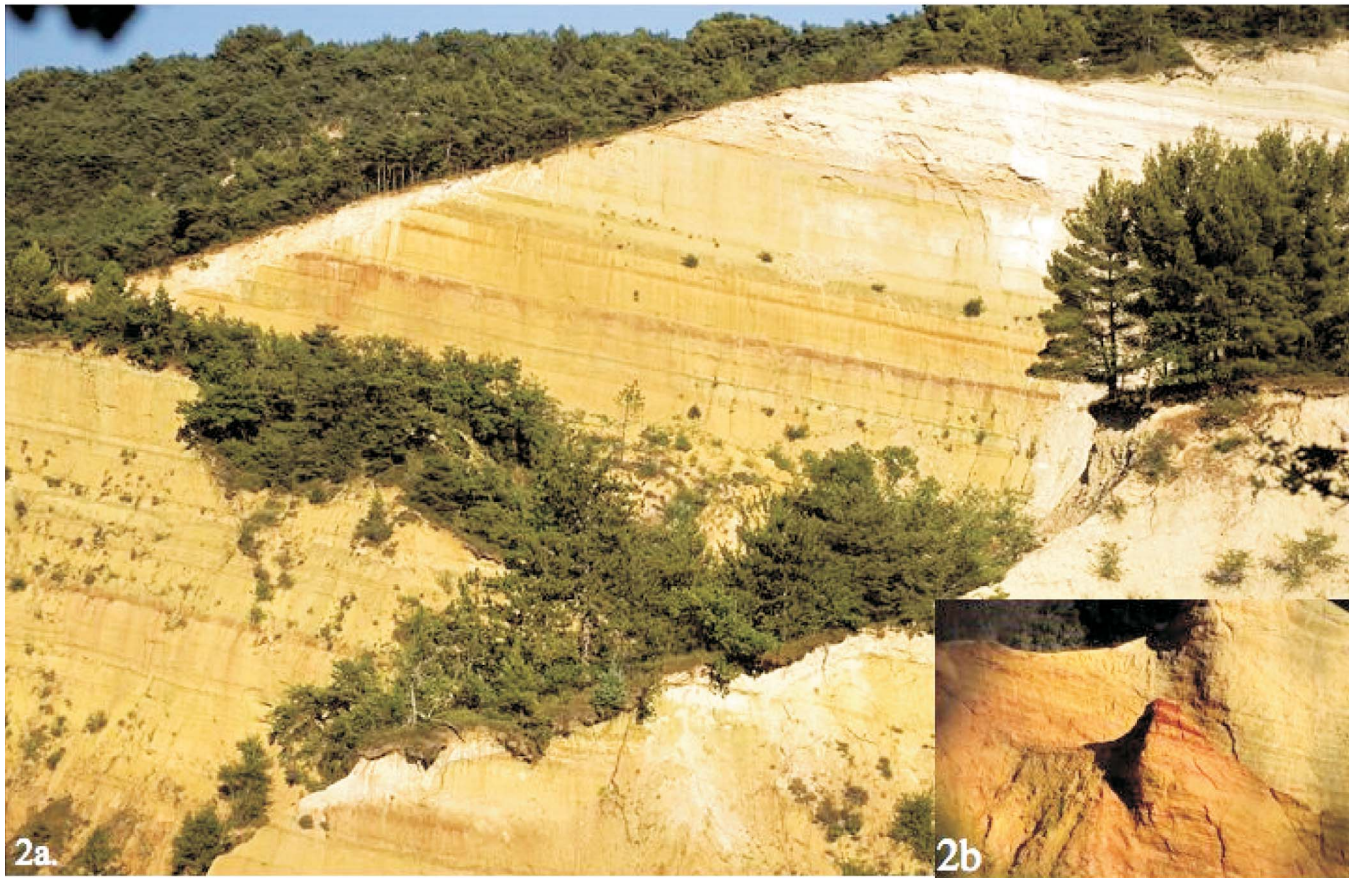


FIGURE 2

Provence owes the beautiful colors of its old houses to the Ogres d'Apt, a sandy-silty clay with bright colors that was quarried for an active trade during the late 19<sup>th</sup> and early 20<sup>th</sup> century. The ogres were formed during the Late Cretaceous, and are often cited as an Upper Cretaceous deposit. Stratigraphic geometry reveals however that the sandy-silty clays belong to the Lower Cretaceous (Aptian). The Lower Cretaceous sands were weathered en masse into bauxite-rich ogres under warm Late Cretaceous climates (Triat 1982). Photograph by Michel Aubry.

The ICS has magnified the role of correlation in the definition of chronostratigraphic boundaries, requiring their selection in association with highly correlatable events. This has been effectuated by substituting the GSSP for the boundary stratotype of the *Guide* (Cowie et al. 1986; Remane et al. 1996). Chronostratigraphic boundaries are defined by GSSPs located in sections that are as continuous as possible, and correlatable by means of pre-selected events.

In agreement with Harland's (1990) philosophy of chronostratigraphy, SCGSL04 interpret this to mean that event-bounded GSSPs alone fix time in the rock record. The abandonment of unit stratotypes allows for a-posteriori-selected horizons to become markers of the passage of time. In this view the stratigraphic record is no more than the convenient register of pre-selected, time-significant events. Chronostratigraphy is subordinated to event-stratigraphy—a (difficult) ruler of geological time. Ultimately GSSPs are substitutes for the scarce radioisotopically datable horizons. In this interpretation of GSSP-based chronostratigraphy, chronostratigraphic and geochronologic units form parallel, redundant ladders, and the proposal by the SCGSL04 to eliminate the chronostratigraphic component is well received in some quarters.

The ICS has given a different interpretation of GSSP-based chronostratigraphy, though. Both Cowie et al (1986) and Remane et al. (1996) preserve the arbitrary role of stratigraphic horizons in defining chronostratigraphic boundaries, insisting that the lithostratigraphic definitions take precedence over the means of correlation upon which they have been selected ("an occurrence of the primary marker does not automatically determine the boundary" [Remane et al. 1996, p. 79]; "The ultimate reference is to rock and not to abstractions" [Cowie 1986, p. 79]; see also Walsh et al. 2004, p. 207-208). GSSPs thus remain the arbitrary stratigraphic horizons that Hedberg promoted as boundary stratotypes.

The deletion of rock-units from chronostratigraphy is thus not simply a natural, logical deduction from the GSSP concept. The inclusion or exclusion of rock units is entirely dependent upon the philosophical principles that underlie chronostratigraphic practice.

#### Benefits of a simplified terminology

Dual terminology is admittedly awkward when applied without rigor. However, is it more difficult to infer a time interval from an outcrop than to infer a group of living organisms from a col-



FIGURE 3

The Sables et Grés de Fontainebleau have a complex history. The sands were deposited during the Early Oligocene (Pomerol 1983). The sandstones, formed much later, result from the silicification of the sands through leaching during the Late Pleistocene (Thiry et al. 1988; the diagenetic episode is narrowed to the Late Pleistocene for the purpose of discussion). Using a single terminology, the sables are Early Oligocene and the (interbedded) sandstones are Late Pleistocene! Dual terminology allows a comprehensive description: The sands are Upper Oligocene (chronostratigraphic position), and the sandstones are a Late Pleistocene feature. Similarly, dual terminology allows clear description of the relation of an intrusive volcanic rock (sill or dike) and the encasing sedimentary rocks. Photographs by Médard Thiry.

lection of fossil bones? There must be concepts far more difficult to grasp than those of rock- and time-units. The two proceed from the same logic that permitted the foundation of stratigraphy by Steno. The principles of stratigraphy were derived from sedimentary successions, upon which relative dating was conceived for a sweeping translation of the stratigraphic record into historical geology (Hutton 1795; Smith 1815; Lyell 1830-1837; d'Orbigny 1852). The latter owes more to the sedimentary record (which covers the largest area of the planet) than to any other rock type. Is it not acceptable then that chronostratigraphic units designate first and foremost sedimentary strata?

Stratigraphic classification is simple precisely because rock- and time-units are distinct. The concrete evidence on the one hand, the temporal inference on the other. The rock record is; its measure and description are direct and reproducible without any margin of error. Time was; its measure is indirect, often difficult, and is imbued with large uncertainties. Should we not base our chronostratigraphic nomenclature on the concrete facts, even if incomplete here and there, rather than on the virtual, even if we are quantifying it increasingly well (i.e., ATS)?

#### A PLEA FOR PRESERVING DUAL TERMINOLOGY IN CHRONOSTRATIGRAPHY

If chronostratigraphy serves as a temporal vernier (Harland 1990; Walsh 2004), the rock-unit concept is clearly superfluous. But is this our only expectation from chronostratigraphy? Could it be that single points connected in a geographic zigsaw pattern but falling on a straight time-line are sufficient to describe the whole rock record and its relation to time? In deep sea stratigraphy, which is dominated by event-stratigraphy, the vernier model is dominant. The latter is perfectly functional for paleo-oceanographic reconstructions and evolutionary studies, for example. However other geological studies, those that involve the architecture of the stratigraphic record itself, or its long-term diagenesis, demand more from chronostratigraphy than reference to the “same time instants”.

SCGSL04's reference to Hedberg's analogy of the hourglass is revealing of vastly different conceptual approaches to time. Hedberg conceives the stratigraphic record in its wholeness, and builds on this to infer time. In a Proustian manner, SCGSL04 conceives each bed (sand grain) as a “capture of successive instants of time”. Nothing is new under the sun! Both approaches



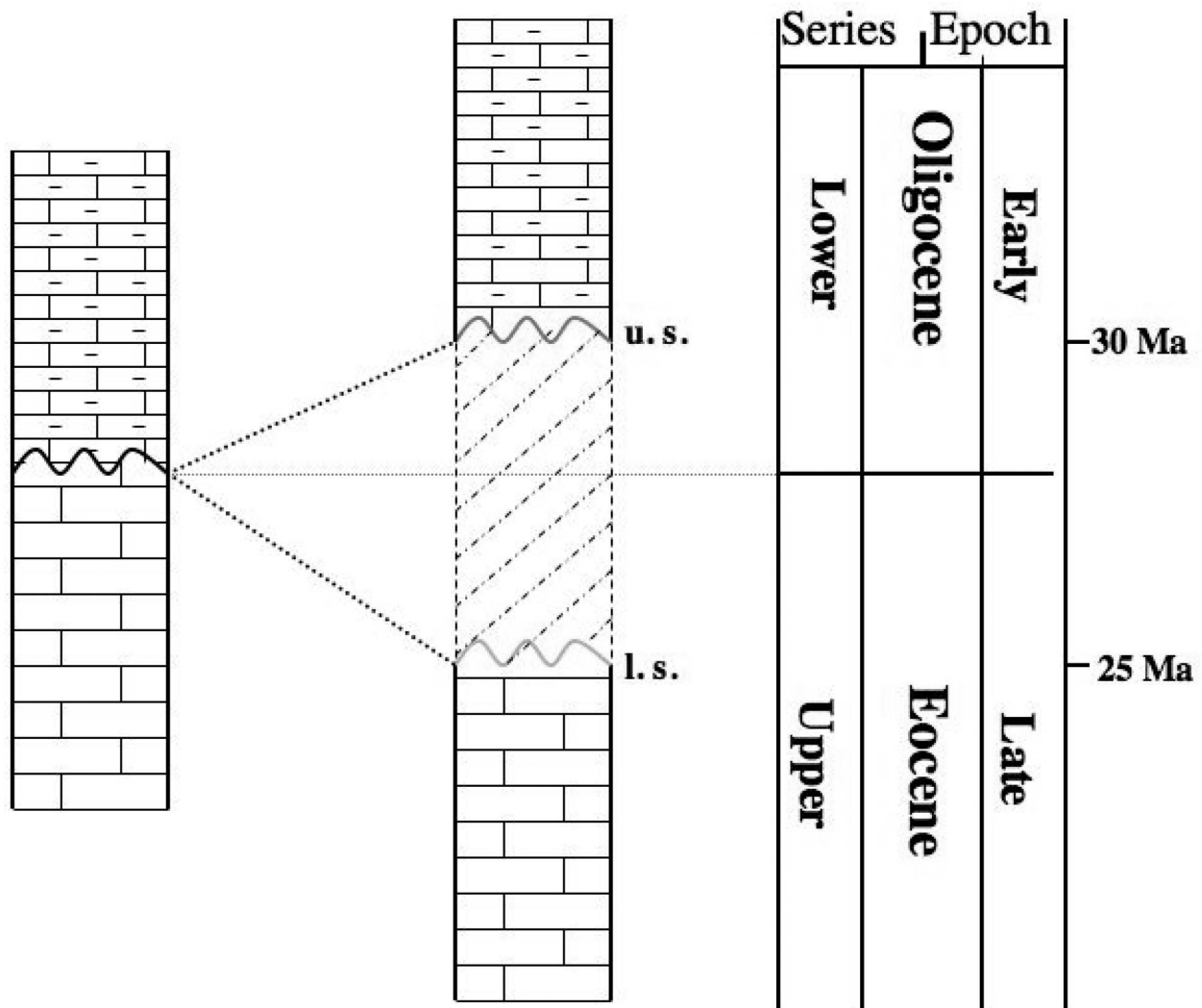


FIGURE 4

Consider a disconformity between Eocene and Oligocene rocks, as a result of Early Oligocene ice-build-up. The erosion cuts cleanly into the Eocene, so that Eocene rocks are in direct, physically unconformable, contact with Oligocene rocks. Resulting from an Early Oligocene eustatic fall (~30 Ma), the unconformity may be said to be Early Oligocene. This remains insufficient to describe the unconformity (Aubry 1991), which consists of two surfaces, dated in our case as Eocene (~38 Ma) and Oligocene (~30 Ma). Following SCGSL04, the lower surface would be described as Late Eocene, the upper surface as Early Oligocene, which in turn would indicate that the lower surface formed during the Late Eocene, the upper surface during the Early Oligocene. If the second part of our conclusion is correct, the first one is plainly incorrect. The lower surface, said to be Late Eocene, formed during the Early Oligocene. It is the result of Early Oligocene erosion of rocks deposited during the Late Eocene, down to the level of the surface. This surface is linked to *Early* Oligocene history but it belongs to the *Upper* Eocene stratigraphic record. This surface is Upper Eocene. Dual nomenclature is required to comprehensively describe and explain the stratigraphic relationships in this case.

demand a leap of imagination. As a palliative to the discontinuous nature of the stratigraphic record at historical chronostratigraphic boundaries, one conceives of virtual isochronous horizons as spring-boards to geological time; the other, dismissive of the stratigraphic record because of its incompleteness, focuses on the few places where stratigraphic continuity may restore the full passage of time.

Can we hope that the passage of time be fully restored, down to the *instant*, anywhere? Can we ever determine, with all its physical and chemical attributes, the thin layer of sediments that was being deposited at a precise moment (Fig. 1)? Assuming that GSSPs represent “chronostratigraphy in action” (moments when specific sand grains hit the bottom of the hour-glass), how

will we describe less fortunate sections whose sediments may have undergone multiple cycles of diagenesis following lithification? If an exposure exhibits mixed, interbedded lithologies that formed at different times (e.g., sands deposited during the Early Oligocene and sandstones formed during the Late Pleistocene, Figs. 2, 3), how would we determine which lithology is chronostratigraphically significant (the Early Oligocene sands or the Late Pleistocene sandstones)?

The abandonment of rock-units (i.e., lower/upper) would deprive our language of a temporal perspective, and lead to confusion with regard to processes and their products (Figs. 2-4). *Lower* and *Upper* contain a plurality of dimensions, including length, width, thickness, which are directly measurable. *Lower*

and *Upper* also incorporate *Early* and *Late*, themselves virtual references with regard to beginning, end and duration. However, as noted above, *Early* and *Late* do not implicitly encompass *Lower* and *Upper*. The two systems do not require being parallel; they are complementary. Their simultaneous use avoids semantic confusion and illogicality (Appendix 1, Fig. 4). Moreover, if duality is abandoned for the chronostratigraphic hierarchy, why should it be preserved for aspects of stratigraphy that relate to it? (Appendix 2).

Far beyond anything else, however, I see one essential reason for preserving dual nomenclature in chronostratigraphy. Stratal geometry is elemental to time.

### Stratal geometry

The diversity of techniques at our disposal to date strata (thus events) should not conceal the fact that geological time is rooted in geometrical relationships between blocks of strata. Even paleontology, which has held the leading role in rock dating for almost 200 years, needs association with the stratigraphic record to tell of past times. Undescribed fossils removed from the outcrop without indication of origin have no more temporal significance than fossils reworked in a riverbed.

Central to the discovery of deep time was Hutton's understanding of the significance of stratal geometry. At Siccar Point he understood and demonstrated that a *lower* unit of subvertical beds was much older than an *upper* unit of subhorizontal beds from which it was separated by an erosional surface. Geometry was indicative of two successive cycles of marine deposition—uplift—folding—massive erosion. This double cycle still conveys a more powerful idea of the depth of geological time than any number does. Would we truly understand 4 Ga without 4 billion years of recorded geological history? Would the inhabitant of a solar planet frozen in time, similar to our moon, understand 4 Ga? What is now called *Deep Time* was discovered simply through the observation of current processes of deposition and erosion (Hutton 1795; cf. Repcheck 2003), with no preconception of time (e.g., deep time was discovered independently of any concept of faunal change). (It is interesting to note in passing that evolution and geological time were discovered separately. Indeed, Hutton had provided Darwin with all the time needed for evolution by natural selection to operate ["I see no vestige of a beginning, no prospect of an end"] but Lyell and others in the 19<sup>th</sup> century were already preoccupied with numbers!). Steno (1669 in Scherz 1969) had also relied on stratal geometry (principle of horizontality) to determine relative age (principle of superposition). The early/late category of chronostratigraphy is thus tied irremediably to its lower/upper category through the *below-older/above-younger*-determination implied by superposition. The duo *early-late* is not specific of stratigraphic position because it applies also (and foremost) to processes (e.g., early Miocene diagenesis; Late Triassic volcanism; late Cretaceous mass extinction). Geological time is rooted in the distinction between *lower* and *upper*.

Stratal geometry remains a first pre-occupation in field mapping. It is preponderant in disciplines such as seismic stratigraphy and sequence stratigraphy. It constitutes the ultimate means to date intervals barren of fossils or with massive reworking. It is the arbitrator of controversial interpretations of age when diagenesis is massive, as for the Ogres d'Apt and Grés de Fontainebleau (Figs. 2, 3). French stratigraphic committees recognize only the rock-unit of chronostratigraphy. *Inférieur* (lower) and *supérieur* (upper) directly refer to superposition,

and time is an inference. Finally, and critically, the development of the most robust, cyclicity-derived time scales, such as the Neogene and Late Triassic Astrochronological Polarity Time Scale (APTS; Lourens et al. 2004; Hilgen et al. 2006; Olsen et al. 1996, 1999) make full use of stratal geometry. In such scales time-units are determined by the superimposition of determined orbital periodicities on the rock-units themselves. Rock-units are fundamental to the construction of the APTS (Hilgen et al. 2006).

### CONCLUSIONS

Chronostratigraphic classification and nomenclature are both the starting point in a learning experience and the culmination of stratigraphic research. Chronostratigraphy is a science with its principles and rigorous logic. The proposal by SCGSL04 abides by the dissident view on the purpose and practice of chronostratigraphy that Harland (1990) has best articulated on behalf of many English stratigraphers. It must be considered at the fundamental methodological level. Its international acceptance would imply a shift in emphasis, with the severance of time-units from their foundation. In this case, the SCGSL04 proposal would be operative if all chronostratigraphic boundaries were known satisfactorily with regard to "absolute" time. For now, this is at best premature, if not utopian.

Simplification is worthy when it increases scientific clarity. If time- and rock-units were synonymous, the deletion of the latter could only be welcome. However it is clear that rock-units hold more significance than time-units. They should be retained.

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## APPENDIX 1

Examples of semantic difficulties and illogicality that would result from the abandon of dual chronostratigraphic terminology. It is common in written literature to refer to rocks and time by adding appropriately lower or early (Lower Eocene is understood as Lower Eocene rocks; early Eocene as Early Eocene time).

Statements 1 a, b: The rock record consists of rocks not of time. It is described in meters, not in million of years. Durations are inferences and may differ, sometimes substantially with methodologies. Time should not be assimilated with thickness because the latter is a function of it: sedimentation rates vary, stratigraphic gaps occur, etc.

Statements 2a, b: both statements are meaningless because by definition, the early Eocene is 6.5 m.y.-long, just as year 2005 was 365 days long whether in Eurasia, America, Antarctica, etc. Early and Late is ignorant of geography. In contrast, Upper and Lower are geographically dependant.

Statements 3a-c: Unless *stratigraphic record* is incorporated these texts are ambiguous. Early and Late apply well to the original sediments. e.g., the Late Carboniferous swamp deposits produced over time the Upper Carboniferous coals; the Late Cretaceous accumulation of calcareous planktonic shells produced a body of rocks now called the Upper Cretaceous Chalk. To refer to the metaphor in SCSGL04 the rock record (upper-lower) is to the sediment what a glacier is to snow accumulation.

Statement 4a, b: In both cases diagenesis has affected en masse a rock unit, not the original sediment as it was being deposited.

	<b>Statement based on simplified chronostratigraphic nomenclature</b>	<b>Statement based on dualistic chronostratigraphic nomenclature</b>
1a	The Early Miocene is 20m thick in Basin BA and 200 m thick in Basin BB	The Lower Miocene is 20m thick in Basin BA and 200 m thick in Basin BB
1b	The Early Eocene is 50 m thick in Basin BC, and represents 5 m.y. of Early Eocene.	The Lower Eocene is 50 m thick in Basin BC, and represents 5 m.y. of Early Eocene.
2a	The Early Eocene in Basin BC is 100 m thick	The Lower Eocene in Basin BC is 100 m thick.
2b	The Early Eocene in Basin BC is 3 m.y.-long	The Lower Eocene in Basin BC represents 3 m.y. (of Early Eocene time]
3a	The Early Eocene overlies the Late Miocene [in a tectonically active area]	The Lower Eocene overlies the Upper Miocene.
3b	The Early Eocene of Basin BD is reworked in the Late Miocene of basin BE	The Lower Eocene of Basin BD is reworked in the Upper Miocene of Basin BE.
3c	In the Townsville area the Late Carboniferous is discordant with the Late Ordovician	In the Townsville area the Upper Carboniferous is discordant with the Upper Ordovician
4a	Alteration transformed Late Oligocene sands into Late Pleistocene sandstones.	Alteration transformed the Upper Oligocene sands into Late Pleistocene sandstones
4b	The Late Cretaceous Ogres d'Apt result from the weathering of the Late Aptian sands.	The Late Cretaceous Ogres d'Apt result from the weathering of Upper Aptian sands.



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## APPENDIX 2

The abandonment of dual terminology in chronostratigraphy may have unfortunate—although logical—consequences, as shown in these examples.

Statement 1: See Appendix 1, statements 1 a, b

Statement 2: note the loss of temporal perspective when only temporal words are being used. Statement 3: See Appendix 1, statements 1b, 2a, b

Statement 4: Time can never be “truncated”; it is never “missing”. It may not be represented by rocks, but it passes uninterrupted.

Statement 5: As statement 2. If *stages* are abandoned, why should *ages* be preserved? And if stages are preserved why should ages be abandoned? The two are complementary, not parallel concepts. Should both stages and ages be abandoned for an up-bottom stratigraphy in which the series/epoch boundaries are at the lower end of the hierarchy?

Statement 6: If chronostratigraphy does not formally differentiate rocks and time, why should we differentiate between fossils and species? Can we agree that fossils belong to the stratigraphic record (they are rocks), and species to time. Can we agree that a species cannot be reworked?

	<b>Statements based on dualistic chronostratigraphic nomenclature</b>	<b>Possible statements resulting from simplified chronostratigraphic nomenclature</b>
1	The Dababiya Quarry Beds comprise five beds. The <b>lower</b> bed (Bed 1) is a 20-cm-thick clay. The upper bed (bed 5) is a 2 m-thick limestone.	The Dababiya Quarry Beds comprise five beds. The <b>early</b> bed (Bed 1) is a 20cm-thick clay. The late bed (bed 5) is a 2m-thick limestone.
2	The Dababiya Quarry Beds contain the biozonal marker <i>Discoaster multiradiatus</i> , and belong to Biozone NP9. Sedimentation at Dababyia during Biochron NP9 was rapid.	The Dababiya Quarry Beds contain the biochronal marker <i>Discoaster multiradiatus</i> , and belong to Biochron NP9. Sedimentation at Dababiya during Biochron NP9 was rapid.
3	Biozone NP9 is 10 m thick in section A and represents 1 m.y. [of Biochron NP9 which is 2 m.y. long	Biochron NP9 is 10 m thick in section A and represents 1 m.y. [of Biochron NP9 which is
4	Biozone NP9 and Magnetozone C25n are truncated in Section B	Biochron NP9 and Magnetozone C25n are truncated in Section B
5	The Ieper Formation constitutes the Ypresian Stage, and represents the Ypresian Age	The Ieper Formation constitutes the Ypresian Age.
6	Jurassic fossils are reworked in the Upper Miocene chalk	Jurassic species are reworked in the Late Miocene chalk

