Terminology of geological time: Establishment of a community standard

Marie-Pierre Aubry[1], John A. Van Couvering[2,] Nicholas Christie-Blick[3], Ed Landing[4], Brian R. Pratt[5], Donald E. Owen[6], and Ismael-Villafranca Ferrusquía[7]

[1] Department of Earth and Planetary Sciences, Rutgers University, Piscataway NJ 08854, USA (aubry@rci.rutgers.edu)

[2] Micropaleontology Press, New York, NY 10001, USA (vanc@micropress.org)

[3] Department of Earth and Environmental Sciences and amont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA (ncb@ldeo.columbia.edu)

4 New York State Museum, Madison Avenue, Albany, NY 12230, USA (elanding@nysed.gov)

5 Department of Geological Sciences, University of Saskatchewan, Saskatoon, Saskatchewan SK7N 5E2, Canada (brian.pratt@usask.ca)

6 Department of Earth and Space Sciences, Lamar University, Beaumont, TX 77710 USA, (deowen@lamar.edu)

7 Universidad Nacional Autónomo de México, Instituto de Geologia, México DF (ismaelfv@servidor.unam.mx)

ABSTRACT

It has been recommended that geological time be described in a single set of terms and according to metric or SI ("Système International d'Unités") standards, to ensure "worldwide unification of measurement". While any effort to improve communication in scientific research and writing is to be encouraged, we are also concerned that fundamental differences between date and duration, in the way that our profession expresses geological time, would be lost in such an oversimplified terminology. In addition, no precise value for 'year' in the SI base unit of second

has been accepted by the international bodies. Under any circumstances, however, it remains the fact that geological dates – as points in time – are not relevant to the SI. Known dates may define durations, just as known durations may define dates, or dates may simply be punctual references that support historical narratives, but dates are not quantities. Furthermore, dates, as datum points, belong to a specific type of guiding information that is in constant use not only by the disciplines that explore the unwritten past, but in the physical sciences and engineering as well. Accordingly, we recommend a new standardization of the distinction between geohistorical **date**, in years before present expressed in 'annus', symbol 'a', with the multiples 'ka', 'Ma', and 'Ga' for thousands, millions and billions of years ago, according to a convention that has been very widely adopted during the last 30 years, and geohistorical **duration**, expressed in 'year', symbol 'yr', with multiples 'kyr', 'Myr' and 'Gyr', respectively, as the most appropriate among the various formats in the current literature. Agreement on these two sets of terms throughout the wide community that deals with paleochronology would remove a false impression of improvisation and uncertainty as to appropriate terminology, and would lead to more effective communication in areas where a simplified SI-compliant terminology would be less, not more useful.

INTRODUCTION

The dispersal of knowledge, in science as elsewhere, results in conceptual drifts from which new paradigms often emerge. Typically this requires rectification of initial misunderstanding and miscommunications that arose because the conceptual differences were concealed under a common terminology. In the latter half of the last century three major works were published explicitly to clarify the concepts and terminology of the Earth sciences: the *International Stratigraphic Guide* (Hedberg 1976; Salvador 1994), the *North American Stratigraphic Code* (North American Commission on Stratigraphic Nomenclature [NACSN] 1983; 2005) and the *Glossary of Geology* (cf,, Neuendorf et al. 2009). Two issues that were addressed in these basic reference works have primary scientific significance because they concern the manner in which geological time is extracted from the stratigraphic record, which in turn is reflected in the editorial style adopted by the scientific literature. One issue is the use of "time-rock" or dual nomenclature, as the very name of chronostratigraphy suggests (Zalasiewicz et al. 2004, 2007; Aubry 2007a; Ferrusquía et al., this volume; Owen, this volume). The other issue is the distinction bewteen date versus duration (Aubry, this volume; Ferrusquía et al., this volume). In practical terms, this is the differentiation in the geohistorical sciences between points in time calibrated, for example, in 'Ma' (with a specific meaning of millions of years before the present), and quantities of time measured in 'Myr' (as a symbol derived from an abbreviation, among others, for millions of years). Although very well understood by the greater part of the geohistorical community, this distinction is held to be irrelevant by those who argue that "it becomes necessary to define a year in terms of the SI unit of time, the second" (http://www.iupac.org/web/ins/206-016-1-200), even though only quantities are considered in the *Système International d'Unités* (Bureau International des Poids et Mesures [BIPM] 2006). In the latter view, the difference between date, as a qualified quantity, and duration, as any quantity, is not important. To further complicate matters, the consistent usage of 'Ma' over the past several decades in referring to dates in all widely consulted geological time scales, as compared to the increasing multiplicity of different terms for durations, has had the effect of giving 'Ma' a sense of legitimacy as a symbol for any kind of time at all.

It is our view that the geohistorical profession has a valid practical interest in a stable, separate terminology for date and duration. To this end, we here review temporal terminology, in various usages and codifications across science, to arrive at standardized symbologies, one for duration in years and the other for dates in years before present, that are scientifically justifiable, consistent with the geohistorical literature, and impossible to confuse with one another. These terms are appropriate for all those who work with paleochronology or "reconstructed time", from human evolution to the origin of the solar system, and their adoption by this community will bring about a level of standardization that has long eluded us. To go beyond this and seek agreement across the spectrum of geochronologists, astrochronologists, stratigraphers and prehistorians on a definition for a "non-SI unit" (see below) for 'year' as a fixed quantity of seconds, we leave for the future.

Statement of the problem

Most workers in subjects where paleochronology applies, stratigraphers in particular, are accustomed to distinguishing two temporal concepts, **date** and **duration**, distinguished by the symbols that follow the numerical year value. Under this convention, 'ka', 'Ma', and 'Ga', for thousands, millions and billions of years before present, have been used fairly consistently for the age of a specific moment in the geological past, and other symbols such as 'kyr', 'Myr', 'Gyr' or variations on this usage (i.e., 'my', 'm.y.', 'm.yr', 'Myrs' and so on) are used to specify durations of the same scope (see for instance NACSN 2005).

Unlike most of the geohistorical community, however, some geochemists and geochronologists working with isotopic dating do not recognize a distinction between date and duration, apparently because their research is focused on age as a quantity of years, calculated directly from a quantity of isotopes, with little reason or interest to express ages as points in relative time. Members of this group have stressed that the 'year' should be defined in terms of the SI base unit of time (e.g., Renne and Villa 2004; Villa and Renne 2005; Rose 2007). This issue has been raised in broad forum discussions, as well as in e-mail exchanges (we note particularly the instructive discussion between P. Renne and I. Villa and the present authors, May-June 2009). This initiative led to the creation of a joint IUPAC-IUGS (International Union of Pure and Applied Chemistry - International Union of Geological Sciences) task group to examine the case (Renne 2007). This group has recommended, provisionally, to (1) abandon the use of distinct terms for different views of time; (2) to adopt 'a' from 'annus', the Latin nominative singular (Milton 2005) as the symbol for the quantity 'year'; and (3) to define 'a' in a fixed value of seconds, the SI base unit for time, to "bring the Earth and Planetary Sciences into compliance with the SI standard regarding units of time (http://media.iupac.org/reports/provisional/abstract09/villa_300609.html). The goal of the task group is to “reconcile current inconsistencies between values used in geological and planetary sciences on the one hand, and those used in the nuclear physics and chemistry communities on the other” (in http://www.iupac.org/web/ins/2006-016-1-200; cf. Holden et al., 2009).

The BIPM currently does not recognize any time unit other than the second. The guide to authors of the American Geophysical Union (AGU) (cf. http://www.agu.org/pubs/author_style_guide.pdf) follows the IUPAC-IUGS task group in treating ‘a’ as a symbol for year, while at the same time identifying dates for chronostratigraphic boundaries as abbreviations, for example, “70 m.y. ago” and “2,300 m.y. ago” (op. cit, p. 18) rather than “70 Ma ago” and “2.3 Ga ago” as this logic would suggest, let alone the conventional “70 Ma” and “2.3 Ga”. *Geological Magazine,* which instructs authors to “Use ka, Ma, Ga for thousands, millions and billions of years, both for dates and for time differences (IUGS standard)” (http://geolmag.geoscienceworld.org/Geo_ifc.pdf, “articles”) is more internally consistent. By contrast, Calder’s geological time scale (1983), to which the *CRC Handbook of Chemistry and Physics* (Lide 2000 to 2009) refers, uses ‘y’ (year) as the symbol for both dates and duration.

In that the unit ‘year’ is not recognized by the BIPM (2006) even as a Non-SI Unit accepted for use of the International Sytem of Units, neither with the symbol ‘a’ nor with ‘y’ or ‘yr’, the editorial style adopted by the noted journals, in an attempt to conform with SI standards in this regard, actually conflicts with the *Guide for the use of the International System of Units (SI)* which “recognizes that situations on occasion will require the use of time-related units other than those given in table 6 (minute, hour, day); such as using intervals of time be expressed in weeks, months or years. In such cases, if a standardized symbol for the unit is not available, the name of the unit should be written in full” (Thomson and Taylor 2006, p. 8, 5.1.1). In other words, even though these editorial styles (among others that could be cited) depart from established convention, and also lose conceptual discrimination where they recommend using the same symbol for duration and date, they nevertheless fail to conform to the SI.

DATE AND DURATION: TWO DISTINCT ENTITIES

The debate over distinguishing **date** from **duration**, as exemplified by an exchange in GSA-Today (Renne and Villa 2004; Okulitch 2005), is not the first time that conceptual nuances in geological language have been at issue. As in all such confrontations, resolution requires that the concepts under discussion first be clearly identified. In this case, the complexity of our relationship to time (Aubry, this volume) must first be appreciated to understand why the symbols used to express geohistorical date and duration are important.

Human experience, to be brief, makes us aware of two components of time. These are intervals during which history unfolds, and specific instants that may define the limits of an interval or simply act as before-and-after markers within an interval. The interval of a human life, with its limiting and marking events – birth, marriage, children, and death – is the most vivid example, but the difference between intervals and events in written and oral history is also intuitively understood. It is our relatively newfound understanding of what has been called "deep time", with intervals measured in spans up to millions of years and delimited by unwitnessed events far beyond human experience that must be recreated from features of the lithosphere, that allows the temporal continuum of paleochronology to be reconstructed and understood as a historical narrative, in the same way (if not on the same scale) as we experience time in human terms.

In the direct parallel between calendars and geological time scales, historical narrative is expressed in two forms. Duration may be either identified in a relational series ("March 1789 AD"; "Miocene Epoch") or measured numerically ("30 days"; "18 million years"). Dates are points in time that are also identified either relationally ("March 25, 1789 AD"; "the beginning of the Miocene"), or numerically ("1,789 years, two months and 25 days after the birth of Christ"; "23.03 million years before present"). In the calendar context, duration and dates are both informally characterized by a number and the word "year", but with different formats. Referring to the Julian calendar, 17 AD is also "Year 17", but this is not the same as "17 years". The latter is a *measurable quantity,* and the former is a *temporal point of reference;* the capitalization and the position of the word "year" determines the significance of the number 17. In the geological time scale, the meaning of the number is determined by the use of a symbol such as 'Ma' to imply date, and 'Myr' (or similar) to imply duration. Thus, the expression "17 Ma" is homologous to "17 AD", while the expressions "17 Myr" and "17 years" are comparable.

A useful analogy is to liken distance in time to distance in space. In space, a distance between two geographic points is a quantity that can be measured in meters (an SI base unit). The end points are not quantities, although they can be characterized in reference to the distance in meters from other points. Consider five exits on a highway, named for kilometer posts 1, 6, 13, 18 and 23. The distance between Exit 1 and Exit 18 is 17 km, but it is not 17 exits or 17 km-posts. Time durations are homologous to geographic distances, while geological dates are homologous to exits and km-posts. Exit 18 can only be at a particular location on the highway, just as 18 Ma can only be at a specific moment of the Miocene Epoch. In contrast, there is a literal infinity of 17 km-long intervals between Exit 1 and Exit 23, just as there is an infinity of 17 Myr-year long intervals between the beginning and end of the Miocene. The difference in terminology is also clearly seen when we refer to cycles and rates, where there can be a 2 Myr periodicity, but not a 2 Ma periodicity where 'Ma' refers to a specific point in time.

The International Organization for Standardization [ISO] (2004) has devoted a full article (ISO 8601; see also http://en.wikipedia.org/wiki/ISO_8601) on the use of symbols to differentiate dates and duration, leaving little room to question whether two sets of symbols should also be used with regard to geological time. Insisting that the same symbol be used for *both* duration and dates in paleochronology would deprive the profession of the same subtle, but essential distinction in analyzing geohistory that is in use all the time in personal history. Furthermore, treating dates as quantities defeats the purpose "that SI units must obey a distributive law" (Renne and Villa, 2004), unless negative numbers are accepted for dates, which refer back to a point in the past specifically "before present". The analogue to dates "BC"(Before Christ) in the Julian calendar is appropriate (Aubry, this volume).

In sum, the two distinct sets of symbols are needed to distinguish **duration** as a quantity, a divisible entity, and **date** as a point of reference in time. Without this distinction, the arrow of time lacks polarity.

SI CHRONOLOGICAL UNITS

Time is one of the four dimensions, and thus one of the four objectives of SI standardization, to "establish fundamental standards and scales for the measurements of the principal physical *quantities*" (BIPM, 2006, p. 95; emphasis added). By this definition, time units within the International System of Units apply only to quantities of time, or duration. They do not – and cannot -- concern dates, which are not quantities but quantified points. Indeed, the BIPM (2006, p. 116) specifies that the SI base quantity of time is duration ("time, duration").

Duration is at the core of most experiments in physics and chemistry, and is central to understanding planetary processes as well. In dealing with biotic, tectonic, climatic, or oceanographic changes on a geohistorical scale, rates (a function of duration) confer predictability, just as in physics and chemistry, but in this context they can only be assumed in models of the past, and are not elements of testable observations in real time. In paleochronology, furthermore, physical and chemical rates are projected far beyond measurable limits, to interpret such features as the accumulation or decay of radioisotopes and the periodicity of orbital dynamics (Hilgen and Kuiper, 2009). In these circumstances, the view that time in physics and chemistry on the one hand, and in geohistorical sciences on the other, can be measured in the same way, is not as logical as it seems.

The BIPM (2006) recognizes seven "SI base quantities" represented by seven "SI base units" (Table 1), which together with "derived units" – i.e., "products of power of base units" (op. cit., p. 116) -- form "the coherent system of SI units". The SI base unit for the SI base quantity "time, duration", *t*, is the second, s. The BIPM has also approved "a series of prefix names and prefix symbols to form the names and symbols of the decimal multiples and submultiples of the SI units. SI prefixes are strictly powers of 10" (op. cit., p. 121; Table 2). With regard to time, the only Non-SI units accepted for use with the International System of units of time, are the uneven multiples of seconds*, minute, hour* and *day* (Table 3), which only persist because of their deeply entrenched usage, and are not to be used with SI multipliers (op. cit., p. 122, 124) to create such units as kilodays or milliminutes. The basic unit of paleochronology, the 'year', is not currently recognized at all, but the BIPM manual notes that "individual scientists should also have the freedom to sometimes use non-SI units for which they see a particular scientific advantage in their work" (op. cit., p. 123).

To define the year as a non-SI unit presents difficulties, even as an observed quantity let alone as a geohistorical unit. The IUPAC-IUGS task group is considering a definition of the quantity 'annus' on the basis of (Year) 2000 AD, where 1 annus (1a) = 3.1556925445×10^7 s (Holden et al. 2009 personal communication May-June 2009). An earlier attempt by Holden (2001) was cited in Renne and Villa (2004), in which the symbol was not 'a' but 'y'. On the other hand, the *Manual of the International Association of Astronomers* (IAU) states that "The IAU has used the Julian century of 36 525 days in the fundamental formulae for precession, but the more appropriate basic unit for such purposes and for expressing very long periods is the year. The recognised symbol for a year is the letter a, rather than yr, which is often used in papers in English ... Although there are several different kinds of year (as there are several kinds of day), it is best to regard a year as a Julian year of 365.25 days (31.5576 Ms) unless otherwise specified." (Wilkins 1989, p. S24).

The use of the unit 'annus', with the symbol 'a', to mean the quantity 'year' has many problems. As noted above, there is no SI symbol for year (BIPM 2006), even though formulae are given (op. cit., www.bipm.org/en/si/si_brochure.chapter 4/conversion_factors.html; http://physics.nist.gov/Pubs/SP811/appenB9.html) to convert years to seconds, in three quantities:

a simple 365 days, a sidereal year, and a tropical year. Thomson and Taylor (2008, p. 23) state that there is “no universally accepted symbol for the year” but remark with reference to the ISO that “Ref. (4: ISO 80000-3) suggests the symbol ‘a’. This reference shows the symbols ‘a’ and ‘a_{trop}‘ for “year, tropical year” on the chart entitled “Other non-SI units given for information, especially regarding the conversion factors” (ISO 2006). As noted above, the symbol ‘a’ is used by IAU for a non-SI unit, the Julian year. The symbol ‘a’ for year, as an “incoherent unit”, was proposed by the Commission for Symbols, Units and Nomenclature (SUN Commission) of the IUPAP (Fleury et al. 1962, p. 28), to be subsequently abandoned. The American Institute of Physics (AIP), however, simultaneously expressed its preference for ‘yr’ instead (Wolfe 1962, p. 19). The issue here is that if ‘a’ were to be accepted for “year” in any consensus, this would lead back to “Ma b.p.”, “Ma ago”, or some other needlessly stilted phrase in paleochronology. Second, while there is no chance that geohistorians will ever deal with dates in the 10^{15} year range, ‘a’ as a symbol for a non-SI unit of time compatible with multipliers (unlike ‘min’, ‘h’ or ‘d’; Table 3) would present an irresolvable conflict, since the symbol for petayears would then be ‘Pa’, which is preoccupied by the pascal, a "coherent derived unit in the SI with special name and symbol" (BIPM 2006, p. 118).

The fact remains, that if ‘year’ is difficult to identify in modern science, it is merely a convention in geohistory. Geohistorians deal in models, in which probable values are given to features in the rocks in order to provide a reconstruction of what may actually have happened. Measuring true duration in the unrecorded past is literally impossible, so what remains are constantly adjusted approximations. On top of this, the astronomical year of paleochronology is not a fixed quantity, by whatever aspect it is measured, but changes over time. A value based on a modern year does not apply in the more distant past with which we are concerned. Finally, a formally defined non-SI unit for year, if somehow agreed, would not necessarily lead to scientific unification as Renne and Villa (2004) hope, because each of the different methods that are used to estimate geohistorical time would use it independently. In addition, ostensible conformity to the

SI would almost certainly be counterproductive, by imposing a fiction of mathematical precision and accuracy that only concealed the reality.

STANDARD USAGE IN PALEOCHRONOLOGY

Given that it may not be appropriate nor apparently desirable to apply SI standards for time terms in the geohistorical sciences, there is a present need to reach an agreement as to a consistent usage for date and duration. This usage should follow internationally accepted SI style in treating combinations of multipliers and defined characters as “symbols” rather than abbreviations, without periods, and with the SI convention for capitalization.

Geohistorical date (datum, geological age)

In reference to measuring time, *t*, we propose that the symbol for the non-standard quantity 'year' in geohistory should be 'yr', in agreement with the AIP (Wolfe, 1962). As for calculated geohistorical dates, which are stated as a quantity of years before present, the convention is to convert the abbreviation of this statement to a value identified by symbols based on a combination of 'a', from the Latin ‘annus’, and an SI multiplier (Table 2). In this way, “66 Ma”' stands for the abbreviation of "66 million years before present". We note that in the absence of international agreement, the geohistorical community is free to adopt symbols that it finds appropriate, with the provision that there is no conflict with formal SI symbols (specifically, the symbol ‘mA’ for milliampere does not conflict). The *International Stratigraphic Guide* (Salvador, ed., 1994, p. 16), *North American Stratigraphic Code* (NACSN 2005, Article 13 (c), p. 30-31), and *Glossary of Geology* (cf. Neuendorfer, et al., 2009, p. 259, 386, 347) all recommend the use of ‘ka’, ‘Ma’ and ‘Ga’ for dates in years before present. For relatively young dates, the use of ‘a’ alone or with the ‘d’ and ‘h’ prefixes for “deka” and “hecto” (table 2) would appear at first to result in misleadingly young dates because of the common understanding that “before present” means “before 1950 AD.” In fact, the 1950 AD “present” encoded in the abbreviation ‘B.P.’ is wholly confined to a calibration factor in the first step of analyzing ^{14}C ages, and does not apply to the published dates in ^{14}C geochronology or in any other dating procedure (see http://en.wikipedia.org/wiki/Before_Present). In geohistorical terms, then, “before present” or ‘b.p.’ in lower case means just that.

The first definition of ‘Ma’ for a date in geological time is found in Berggren and Van Couvering (1979, p. A506, footnote) as follows: “The abbreviation Ma (Mega-annum [sic]) refers to the unit of yr x 10^6 measured from the present 1950 A.D. by international agreement pastward. It means the same as the cumbersome ‘millions of years before present’ and is a fixed chronology analogous to the calendars tied to historical events.” Setting aside the irrelevant 1950 misconception (see above), this innovation was prompted by the increasing use of numerical dates from radio-isotope geochemistry, and the realization that defining events in biochronology such as FADs and LADs (Berggren and Van Couvering, 1978) could now be related to “absolute” or numerical dates. The convention was expanded in the 1983 *North American Stratigraphic Code* to add ‘ka’ and ‘Ga’.

Although, strictly speaking, a radiometric date is a quantity of years, it is always a quantity anchored to the datum point of the present, when the sample was analyzed. It is the qualification “before present” that changes the *age* (the number of years that the sample has been a closed system) into the *date*, a fixed point in the past. The difference between a date and a radiometric age inherently tied to the present is not obvious, and it became common for many workers to simplify “The Cretaceous/Paleogene boundary is dated to 66 m.y.b.p.” as “The Cretaceous/Paleogene boundary is dated to 66 m.y.” Since “m.y.” also means an un-anchored quantity of years, however, the need to have a different, equally simple term that was specifically for a date led to “66 Ma”.

The best evidence that many geochronologists recognize that ‘Ma’ is for dates and not durations is that they measure the half-lives of radionuclides with multiples of the symbol ‘y’ or ‘yr’ (Dickin 2005, p. 13, table 1.1; Faure and Mensing 2005; Holden 2001-2009). Thus, while it may appear that the symbols ‘ka’, ‘Ma’, and ‘Ga’ are claimed by stratigraphers and geochronologists for two different concepts, once the distinction between radio-isotopic age and isotopic duration (half-lives) is understood, the conflict disappears, and it becomes clear that these symbols are correctly used for dates by stratigraphers and geochronologists alike.

Although dates are just a qualified form of duration, they are a critical component in the vocabulary of paleochronology. Stratigraphic time scales, for instance, consist of dates applied to datum planes, such as magnetic reversals, biochron limits, and chronostratigraphic boundaries (e.g., Berggren et al. 1995; Cande and Kent 1992, 1995; Gradstein et al. 2004), and orbital time scales follow this model as well (e.g., Lourens et al. 2004). The wide and long-standing use of separate symbols for dates is evidence that they fill a basic need (Aubry, this volume), which a unified approach to geohistorical time using only a symbol for a duration alone would not meet.

Geohistorical duration

Appropriate symbols for duration are as important as those for date, duration having a determinant role in the reconstruction of geohistorical time (Aubry, this volume). The recommendation of 'yr' by the AIP (Wolfe 1962) prompted Rankama (1967) to suggest 'Megayear', symbol 'Myr', and 'Gigayear', symbol 'Gyr', as two convenient units for the measurement of time in millions and billions of years, respectively. The *CRC Handbook of Chemistry and Physics* (Lide 2001-2009; sections 2, 11, 14) recognizes both 'y' and 'yr' for year, which would justify 'My' and 'Gy' as well.

Rankama (1967) suggested that these symbols should be internationally acceptable because English had become the principal language of science, and that symbols based on other modern languages were not only increasingly irrelevant, but could lead to confusion with the international standard symbols. In French, for instance, 'yr' avoids potential conflict between 'Ma' for dates and an abbreviation such as 'Ma' for the quantity "millions d'années".

Although the symbol 'yr' is not formally recognized by SI or ISO any more than 'a', it is widely used in paleochronology, for example for the duration of cycles in orbital stratigraphy with the multiples 'kyr' and 'Myr'. Unlike 'a', 'yr' presents no problems with regard to conflicts with SI symbols, whereas ‘y’ is undesirable because ‘Gy’ already exists as the symbol for a SI “coherent derived quantity” for “absorbed dose, specific energy (imparted), kerma” (BIPM 2006, p. 118). Alternatively, classical terms other than ‘annus’, perhaps taken from the Greek or Egyptian mythology, might be considered in place of the English ‘year’.

Recommended community standards

The community of geohistorical sciences will benefit from uniformity in the terms and symbols used for duration and date as distinct components of geological time. As well as ending an often frustrating problem for its authors, standardization will give its terminology a new image of stability in place of almost frivolous indecision. Consistent usage will also project a confidence in the special vocabulary required by our unique view of time.

Recommendation 1: Date. That geohistorical dates, as a point in time derived from the rock record, be expressed in years before the present by the term ‘annus’, symbol ‘a’, with multiples symbolized as ‘ka’ ,'Ma' , and 'Ga' for numerical ages of 10^3, 10^6, and 10^9 years before present. The term ‘Ma’ was defined in this way by Berggren and Van Couvering (1979), expanded to other multiples in the *North American Stratigraphic Code* (NACSN 1983) and recommended in the *International Stratigraphic Guide, 2nd ed.* (Salvador 1994) as well as the more recent editions of the *Glossary of Geology* (cf. Neuendorf et al. 2009). It has been almost universally used in chronostratigraphy since the time scales of Berggren et al. (1985a, b).

Recommendation 2: Duration.. That quantities of geohistorical time derived from the rock record be expressed in years, represented by the symbol 'yr', and multiples 'kyr', 'Myr', 'Gyr', et seq to express numerical duration. This usage is compatible with existing editorial style in most journals that publish research on geohistorical subjects, and represents nothing more than a needed and long overdue consensus in typography, with no change in meaning; it also avoids potential problems that can arise with ‘y’ as the symbol. To use the word ‘year’ as opposed to cognates in other modern languages reflects the current role of English as the *lingua franca* of science today (see also Rankama 1967).

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Base quantity		***SI base unit***	
Name	**Symbol**	**Name**	**Symbol**
length	*l, x, r, etc*	meter	m
mass	*m*	kilogram	kg
Time, duration	*t*	second	s
Electric current	*L, i*	ampere	A
Thermodynamic temperature	*T*	kelvin	K
Amount of substance	*n*	mole	mol
Luminous intensity	*lu*	candela	cd

Table 1. Base quantities and base units used in the SI (from BIPM 2006, p. 112).

Factor	Name	Symbol	Meaning	Adopted
10^{24}	yotta	Y	1 septillion	1975
10^{15}	peta	P	1 quadrillion	1990
10^{12}	tera	T	1 teraillion	1990
10^{9}	giga	G	1 billion	1948, 1960
10^{6}	mega	M	1 million	1960
10^{3}	kilo	k	1 thousand	1960
10^{2}	hecto	h	1 hundred	1960
10^{1}	deka*	da	ten	1960
10^{-1}	deci	d	a tenth of a	1960
10^{-2}	centi	c	a hundredth of a	1960
10^{-3}	milli	m	a thousandth of a	1960
10^{-6}	micro	µ	a millionth of a	1960
10^{-9}	nano	n	a billionth of a	1960
10^{-18}	atto	a	a quintillionth of a	1964

Table 2. Selected SI prefixes. *spelled “deka” in the United States, but “deca” in numerous countries. (from BIPM 2006, p. 121).

Quantity	Unit	Symbol	Relation to SI
Time	minute	min	1 min = 60s
Time	hour	h	1 h = 3600s
Time	day	d	1 d = 86 400s

Table 3. Time NSUs in the the International System of Units (from BIPM 2006, p. 124).