Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

Use and reporting of geochronology and isotope results — style guide

Geological Survey of Western Australia

Contents

Version	Date	Comments
1.0	May 2014	Revisions by Michael Wingate, Chris Kirkland
2.0	November 2020	Revisions by Michael Wingate, Imogen Fielding, Yongjun Lu, Angela Riganti

Use and reporting of geochronology and isotope results — style guide

Why this guide?

An important aim of the Geochronology and Geochemistry Branch at the Geological Survey of Western Australia (GSWA) is to ensure accuracy and consistency in reporting geochronology and other isotope information in GSWA and external publications.

In most cases, the geochronologists are co-authors of GSWA publications that include significant geochronology information, and so have an opportunity to check manuscripts prior to submission to Editing and Publishing (E&P), including explanatory notes submitted via the Explanatory Notes System (ENS). The geochronologists are available to review other publications containing geochronology information, or to assist with questions about geochronology.

For some issues, although there may be no 'consensus' on aspects of style and usage, it is necessary to adopt a clear and easily followed style to achieve consistency, provided the information is accurate.

Units of geological time

The units for geological dates, ages, time intervals, and durations should adhere to the International System of Units (SI) rules, use the 'year' or 'annus' (symbol 'a'), and be measured in 'ka', 'Ma', or 'Ga'. Variations, including 'ky', 'kyr', 'm.y.', 'M.y.', 'G.y.', 'myr', 'Myr', or 'Gyr', or any other abbreviation, should not be used. See relevant discussion by Holden et al. (2011) (see PDF at end of this document).

Time period names follow the ICS International Chronostratigraphic Chart. See a range of useful chronostratigraphic charts and time scales.

Isotope systems and dating methods

Isotope decay systems and dating method notations normally use an 'en' dash between the elements, with the important exception of $^{40}Ar/^{39}Ar$ dating. Dates and ages based on the U–Pb and $^{40}Ar/^{39}Ar$ schemes normally use a forward slash to indicate a ratio between the elements or isotopes. Some common examples are listed below.

Isotope decay system or dating method	*Isotopic date or age*
U–Pb, Th–Pb, U–Th–Pb (i.e. U–Pb geochronology; not U/Pb geochronology)	'U–Pb date' is generic and can refer to several date types: • ^{238}U/^{206}Pb* date • ^{235}U/^{207}Pb* date • ^{207}Pb*/^{206}Pb* date • concordia age • upper or lower (concordia) intercept date • U–Pb crystallization age 'U/Pb date' refers specifically to ^{238}U/^{206}Pb* or ^{235}U/^{207}Pb* date
^{40}Ar/^{39}Ar	^{40}Ar/^{39}Ar date, ^{40}Ar/^{39}Ar plateau age
†Sm–Nd	Sm–Nd isochron date, Sm–Nd whole-rock and (or) mineral isochron date
†Lu–Hf	Lu–Hf isochron date, Lu–Hf whole-rock and (or) mineral isochron date
K–Ar	K–Ar date
Rb–Sr	Rb–Sr isochron date, Rb–Sr whole-rock and (or) mineral isochron date
Re–Os	Re–Os isochron date, Re–Os model age
(U–Th)/He	(U–Th)/He date

†See also the section below on isotope geology

Acronyms

Acronyms should be defined with first use in a manuscript. ENS reports are an exception as the acronym is explained in the footer of the report itself.

The Sensitive High-Resolution Ion Microprobe (SHRIMP) is one of several instruments that use secondary ion mass spectrometry (SIMS) for geochronology. The SHRIMP acronym is widely used, understood, and accepted in international literature.

However in some cases, it may be desirable to also include the acronym 'SIMS'. In GSWA publications, the use of 'SIMS' should ideally be restricted to an explanatory section (e.g. analytical methods) early on and not elsewhere within the manuscript. For example:

> The SHRIMP is one of several instruments that use secondary ion mass spectrometry (SIMS) for geochronology.
>
> The precision of individual SIMS analyses is lower than that of isotope dilution thermal ionization mass spectrometry (IDTIMS) analyses, typically by an order of magnitude.

Isotopic ages determined using the SHRIMP can be referred to as 'SHRIMP U–Pb ages', or 'SHRIMP U–Pb zircon ages' (or other mineral). If it is made clear that all the ages reported in a manuscript are SHRIMP ages, then the acronym can be omitted:

Wang et al. (1996) reported a U–Pb zircon crystallization age of 2715 ± 6 Ma.

The dolerite sill yielded a weighted mean baddeleyite ^{207}Pb*/^{206}Pb* date of 1170 ± 5 Ma (MSWD = 0.95), interpreted as the age of crystallization.

The latter example includes asterisks after the 'Pb' to indicate that the U–Pb data on which the date is based have been corrected for common, or initial, Pb. This usage should be explained early in a manuscript, e.g. 'Pb* indicates radiogenic Pb'.

Some common acronyms in geochronology:

IDTIMS	isotope dilution thermal ionization mass spectrometry
LA-ICP-MS	laser ablation inductively coupled plasma mass spectrometry
LA-MC-ICP-MS	laser ablation multicollector inductively coupled plasma mass spectrometry
MDA	maximum depositional age
MSWD	mean square of weighted deviates
SHRIMP	Sensitive High-Resolution Ion Microprobe
SIMS	secondary ion mass spectrometry

Dates vs ages

In GSWA publications, an isotopic 'date' refers to a numerical result based on one or more analyses, whereas an 'age' refers to the time of a geological event interpreted from isotope results. For example:

Dates of 2630–2590 Ma are interpreted to reflect minor loss of radiogenic Pb.

A metarhyolite of the Toppin Hill Formation yielded a U–Pb crystallization age of 2699 ± 5 Ma (Sircombe et al., 2007).

The dolerite sill yielded a baddeleyite ^{207}Pb*/^{206}Pb* date of 1170 ± 5 Ma, interpreted as the age of crystallization.

There are exceptions, where the usage is entrenched in the literature, such as concordia age, plateau age or model age.

Analytical uncertainties

In all cases, the confidence level of uncertainties should be understood or stated. Weighted mean dates are normally reported with 95% confidence intervals, calculated either as $t\sigma\sqrt{MSWD}$ when MSWD is >1, or as 1.96σ when MSWD is <1 (σ is the standard error of the mean; t is Student's t; MSWD is mean square of weighted deviates).

The confidence level should be stated early in a manuscript that reports several results:

All isotopic dates are reported with 95% confidence intervals, except where noted otherwise.

In specific cases, isotopic dates or ages may be reported with 2-sigma (2σ) uncertainties, although 95% uncertainties are generally preferable for mean ages.

The date or age derived from a single analysis, and those in data tables for individual analyses, are normally quoted with 1-sigma (1σ) uncertainties:

The youngest analysis indicates a date of 1779 ± 17 Ma (1σ), interpreted as a maximum age of deposition.

Two analyses yield $^{207}Pb^*/^{206}Pb^*$ dates (1σ) of 2648 ± 5 and 2524 ± 8 Ma, interpreted as the ages of inherited zircons.

Note the differing positions of the '(1σ)', depending on whether there is one, or more than one, date involved.

The precision of the uncertainty must match the precision of the measurement:

Fourteen analyses yield a $^{238}U/^{206}Pb^*$ date of 412.3 ± 0.8 Ma.

Twenty analyses of zircon rims yield a concordia age of 2690 ± 3 Ma.

Approximate ages, and the use of 'c.'

The use of 'c.' indicates that a date or age is approximate, or has an associated uncertainty that is not being reported.

The terrane was intruded extensively by granitic magma at c. 1830 Ma.

For a list of two or more dates, the 'c.' is not required before each one, and the 'Ma' is needed only after the last one:

… age components at c. 2530, 2448, 2320, 1880, 1830 and 1435 Ma.

… dates of c. 2555 and 2430 Ma.

It is implied that all dates in the list are similarly approximate and that the 'c.' applies to each one. If this is not the case, then the sentence should be rewritten to clarify or emphasize the point.

The 'c.' is not included before an age range that uses an 'en' dash:

… 42 analyses yield dates of 2837–2664 Ma.

In some cases, dates may be reported for which the uncertainties are not included because they are considered not to be relevant or important (e.g. dates that reflect analytical problems or alteration, or for other reasons), and the 'c.' can be omitted:

Five analyses yield $^{207}Pb^*/^{206}Pb^*$ dates of 1843–1812 Ma, interpreted to reflect minor loss of radiogenic Pb.

A date may be intended to represent an exact age, in which case the use of 'c.' would not be appropriate:

The Paleoproterozoic Era extends from 2500 to 1600 Ma.

No mafic rocks were emplaced in this terrane after 1600 Ma.

The word 'about' is preferable to 'c.' when referring to an approximate interval of time:

The volcanic rocks are about 120 Ma older than the granitic rocks.

Ranges of ages, and use of the 'en' dash

Ranges (and lists) of ages are itemized from oldest to youngest. A range defined by two ages can use an 'en' dash (but not a 'c.'):

Sixteen analyses yield dates of 2960–2910 Ma.

However, if the range is preceded by 'between' or 'from', the 'en' dash is not appropriate, and should be replaced by 'and' or 'to', respectively:

> … between 1830 and 1820 Ma.
>
> … from c. 1950 to 1870 Ma.

As with lists of ages, the 'Ma' is needed only after the last age.

Zircon 'populations'

The term 'population' is not used in GSWA publications when referring to zircons (or groups of zircons) within a sample, or to dates or ages derived from analyses of samples.

As in statistics, the term 'population' refers to all the zircons in the rock unit from which the sample was collected, whereas geochronological analyses are conducted on a subset (i.e. sample) of the population.

Refer to 'groups' or 'types' of zircons in a sample, or find a meaningful way to describe them. Groups of ages identified in the results (which may not be representative of the entire *population* in the rock unit) are referred to as 'age components':

> … data indicate a unimodal zircon age component at 1791 ± 10 Ma.
>
> The data indicate significant detrital zircon age components at c. 2670 and 2630 Ma, and several minor components between 2935 and 2710 Ma.

Isotope geology

Although 'isotope' is a noun and 'isotopic' is an adjective, these words are sometimes used interchangeably, although 'isotope' is preferable unless it seems obviously inappropriate. Authors should consider the context in which the term is used, and be consistent throughout a manuscript.

Examples of usage include:

> This Report uses time-constrained Lu–Hf isotope analyses to evaluate crustal evolution.
>
> This section presents new Lu–Hf and oxygen isotope data.
>
> The Nd isotope signatures of the volcanic units are similar to those of the granitic rocks.
>
> Isotope maps are valuable for visualizing crustal architecture.
>
> Zircons with 1.9 Ga model ages also have mantle-like oxygen isotope signatures.
>
> Isotopic dating methods are used to measure the ages of most geological samples.
>
> The isotopic boundary between the eastern and western parts of the terrane coincides with major crustal-scale structures and mineralization.

Notation for isotopes should follow convention and present the mass as a superscript preceding the element, e.g. $^{147}Sm/^{144}Nd$, $^{176}Hf/^{177}Hf$.

Epsilon notation:

ε_{Nd}, ε_{Hf} epsilon notation, indicated by the 'ε' symbol, is used to indicate deviations in parts per 10 000 from Chondritic Uniform Reservoir (CHUR)

$\varepsilon_{Nd(i)}$, $\varepsilon_{Hf(i)}$ the subscript 'i' indicates an initial isotope ratio (i.e. the ratio at the time of crystallization); equivalent to, but preferred over, $\varepsilon_{Nd(t)}$ where t is the crystallization age

$\varepsilon_{Nd(400\ Ma)}$, $\varepsilon_{Hf(400\ Ma)}$ if the crystallization age has not previously been discussed in the text and obvious, the crystallization age (400 Ma in this example) should be specified. This notation is also used to indicate data calculated for a specific date, typically as an aid in comparing data. For example, the ε_{Hf} value at 2000 Ma = $\varepsilon_{Hf(2000\ Ma)}$

Nd and Hf model ages:

Sm–Nd and Lu–Hf model ages are based on the fractionation between elements that occurs during extraction of magma from the mantle to produce a crustal rock. There are different mantle evolution models that can be used to calculate a model age.

T_{DM} (depleted mantle model age): indicates the time at which the isotopic composition of a sample was equivalent to that of the depleted mantle (DM) model

T_{CHUR} (CHUR model age): indicating the time at which the isotopic composition of a sample was equivalent to that of the CHUR model

T_{DM}^{2} (two-stage depleted mantle model age): equivalent to, but preferred over, T_{DM}^{C}.

Oxygen isotope ratios ($^{18}O/^{16}O$) are normally reported in delta notation, as $\delta^{18}O$ (‰) values, normalized to Vienna Standard Mean Ocean Water (V-SMOW).

Geochronology entries in the Explanatory Notes System (ENS)

In the ENS Geochronology subsection for lithostratigraphic units, ages are entered as Inferred, Isotopic, Biostratigraphic, or Paleomagnetic.

Inferred ages are used if the unit has not been directly dated. The age of a unit may be constrained by the ages of other units or events, sometimes quite closely, or the age may be a very broad estimate, even a considered guess. Isotopic (or paleomagnetic or biostratigraphic) ages are used when a specific unit has been directly dated.

For lithostratigraphic parent/child units, the following applies:

- If a child unit (formation, group, member, etc.) is isotopically dated, the maximum and minimum ages of the parent unit remain inferred.
- If the dated child unit is demonstrably at the base or top of the parent unit, the corresponding maximum or minimum age for the parent unit is isotopic.
- If a child unit or general parent unit is isotopically dated at a specific locality, then an isotopic age can be shown on the map for that unit, but not elsewhere, as long as ENS contains the specific age and the specific area in the Geochronology narrative discussion. Editors should scan the Geochronology text to confirm this, if an isotopic age has been used for a unit whose age is otherwise inferred in ENS.

Note that the age range of a unit must be, at most, equal to the age range of any of its parent units. For example, an Aptian formation cannot have a Lower Cretaceous child unit. Built-in checks in ENS prevent units from having ages inconsistent with those of their parent or child units.

Isotopic dates must have the uncertainty entered (also built into ENS), and be directly related to the unit in question. When defining maximum and minimum age constraints for a unit with isotopic dates, use the quoted age — not the age plus or minus the uncertainty. Note that uncertainties for maximum and minimum ages can overlap. In some cases, the maximum and minimum ages will be identical.

The maximum and minimum age fields for a unit should indicate the oldest and youngest dates pertaining to the unit that are considered acceptable (i.e. excluding results that may be geologically unreasonable or otherwise unreliable), even though they may not necessarily indicate the inferred actual age range, which could be narrower. The narrative text field should describe and critically evaluate the geochronology results and explain how the results are interpreted. The narrative should also summarize and provide the best estimate of the actual age of the unit. In cases where several dates should be combined, or where 'old' data need to be re-assessed, it will be necessary to consult a geochronologist.

Where an age is biostratigraphic, a numerical age is generally automatically populated from a look-up table based on the latest accepted ICS International Chronostratigraphic Chart.

ENS geochronology narratives must be checked by a geochronologist prior to the Project Manager (PM) submitting the unit ENS entry for editing:

1. Author sends completed notes to PM
2. PM checks and sends to Chief Geochronologist for geochronology check
3. Chief Geochronologist checks the geochronology section and sends back to PM

A citation and reference to a Geochronology Record or other published source are mandatory for isotopic ages. Should a Geochronology Record not be available at the time of publication of the ENS unit, the unit must be assigned an inferred age, and geochronology results should be quoted in the text as 'GSWA preliminary data'. It is the responsibility of the authors to update their units once a Geochronology Record is published, to ensure consistency between table and text. Below are the approved formats for citing unpublished and published Geochronology Records in ENS — note that the GSWA sample number is always quoted:

(GSWA 123456, GSWA preliminary data)

(GSWA 123456, Wingate et al., 2013; GSWA 678901, Kirkland et al., 2013)

(GSWA 142852, Nelson, 1998b; Sheppard and Swager, 1999)

Inclusion of geochronology results in publications

In most cases, GSWA publications, including ENS entries, should not include lengthy analytical details or tables of geochronology data for GSWA samples. If a Geochronology Record has been published for a sample, then it is sufficient to summarize the relevant points and cite the Geochronology Record, rather than duplicate its content. With sufficient notice, Geochronology Records can be published prior to manuscript or ENS deadlines. For external journal papers, it may be appropriate to include more detailed analytical descriptions, data tables, and discussion of the geochronology results, depending on the focus of the paper.

Authorship of reports and external journal articles

Geochronology and isotope data are integral parts of many geoscience projects undertaken at GSWA. It is important that a geochronologist is involved at an early stage in those projects, as well as during the compilation and interpretation of geochronology and isotope data and writing of publications. It is not reasonable to expect geochronologists to review, correct, and possibly rewrite extensive geochronology-related material in publications at short notice.

It is appropriate and expected that geochronologists be included as co-authors in publications that make use of new geochronology and isotope results, particularly if the results are used to formulate geological models or to change existing ones. This applies to internal or external reports, presentations, external journal articles, and ENS lithostratigraphic units and events that include interpreted geochronology and isotope results.

In the case where an article relies heavily on, or is based mainly on, geochronology and isotope data, the geochronologist(s) should be second or third authors (i.e. rather than tenth!). Also, if geochronologists are authors, then it is both appropriate and efficient for the geochronologists to write the geochronology and isotope-related sections of those manuscripts.

If subsequent papers are written, where there is less emphasis on geochronology, or the paper uses geochronology results that were published several years earlier, it may be sufficient to cite earlier publications rather than include the geochronologists in the author list.

In some cases, geochronology or isotope geology results are obtained from external analytical laboratories under collaborative agreements that stipulate co-authorship and joint publication of results. In these cases, it is very important that external collaborators are offered both co-authorship and the opportunity to contribute to the publication in which the results appear.

Acknowledgements

Depending on specific content, most GSWA and external publications that include geochronology or isotope data should incorporate one or more acknowledgements and logos:

> **Isotope and element / U–Pb analyses were conducted using the GeoHistory laser-ablation ICP-MS and SHRIMP ion microprobe facilities at the John de Laeter Centre (JdLC), Curtin University, which are operated with the financial support of the Australian Research Council and AuScope National Collaborative Research Infrastructure Strategy (NCRIS). [edit red text as required]**
>
> **The TESCAN Integrated Mineral Analyser (TIMA) instrument was funded by a grant from the Australian Research Council (LE140100150) and is operated by the John de Laeter Centre, Curtin University, with the support of the Geological Survey of Western Australia, The University of Western Australia and Murdoch University.**
>
> **Lu–Hf measurements were conducted using LA-ICP-MS at the ARC National Key Centre for Geochemical Evolution and Metallogeny of Continents (GEMOC), via the ARC Centre of Excellence in Core to Crust Fluid Systems (CCFS), based in the Department of Earth and Planetary Sciences at Macquarie University, Australia.**
>
> **Isotope analyses were funded in part by the Western Australian government Exploration Incentive Scheme (EIS).**
>
> **Staff at the Geochronology Laboratory of the Geological Survey of Western Australia are thanked for their diligent efforts in separating minerals for geochronology. (*for external journal articles only*)**

The acknowledgement statements for external analytical facilities tend to change periodically, based on changes in funding sources, for example. Please ask a geochronologist for up-to-date advice on which acknowledgements and logos need to be included.

Pure Appl. Chem., Vol. 83, No. 5, pp. 1159–1162, 2011.
doi:10.1351/PAC-REC-09-01-22

IUPAC-IUGS common definition and convention on the use of the year as a derived unit of time (IUPAC Recommendations 2011)*,**

Norman E. Holden[1,3], Mauro L. Bonardi[1,4], Paul De Bièvre[1,5], Paul R. Renne[2,6,7], and Igor M. Villa[2,8,9,‡]

[1]International Union of Pure and Applied Chemistry; [2]International Union of Geological Sciences; [3]National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY 11973, USA; [4]LASA, Università degli Studi di Milano and INFN, I-20090 Segrate, Italy; [5]Consultant on Metrology in Chemistry, Duineneind 9, B-2460 Kasterlee, Belgium; [6]Berkeley Geochronology Center, 2455 Ridge Road, Berkeley, CA 94720, USA; [7]Department of Earth and Planetary Science, University of California, Berkeley, CA 94720, USA; [8]Institut für Geologie, Universität Bern, CH-3012 Bern, Switzerland; [9]Università di Milano Bicocca, I-20126 Milano, Italy

Abstract: The units of time (both absolute time and duration) most practical to use when dealing with very long times, for example, in nuclear chemistry and earth and planetary sciences, are multiples of the year, or annus (a). Its proposed definition in terms of the SI base unit for time, the second (s), for the epoch 2000.0 is $1\ a = 3.155\,692\,5445 \times 10^7$ s. Adoption of this definition, and abandonment of the use of distinct units for time differences, will bring the earth and planetary sciences into compliance with quantity calculus for SI and non-SI units of time.

Keywords: annus; decay constants; geochronology; IUPAC Analytical Chemistry Division; IUPAC Inorganic Chemistry Division; SI units; units of time.

INTRODUCTION

The International Union of Pure and Applied Chemistry, IUPAC, and the International Union of Geological Sciences, IUGS, set up a task group in October 2006 with the goal of updating the recommendations on radioactive decay constants (and half-lives) for geochronological use, last formalized in 1976.

In the course of the initial assessment, it was noticed that use of units for time in the geological literature is inconsistent both internally and with respect to SI (*Le Système international d'unités*). A source of inconsistency is the perceived contrast between "absolute time", or "age", i.e., the time difference between "now" and an event in the past, and the time difference between two events in the past. This issue is addressed immediately, as it requires neither new experiments nor extensive literature evaluations but only judgment and adherence to SI rules.

---

*Sponsoring bodies: IUPAC Analytical Chemistry Division; IUPAC Inorganic Chemistry Division; International Union of Geological Sciences; Joint IUPAC–IUGS Task Group on Isotope Data in Geosciences: see more details on page 1161.
**This paper will also appear in the official IUGS journal, *Episodes*.
‡Corresponding author: E-mail: igor@geo.unibe.ch

SI AND NON-SI UNITS FOR TIME

The SI unit of time, the second (s), is impractical for expressing very long time intervals both for earth scientists and nuclear physicists alike. In such cases, other units are accepted for use with the SI. For geological and astronomical applications and for use with long-lived radioactive nuclides the year, or annus (symbol, a), is used [1–4].

The definition of the year in terms of the SI base unit, the second, is no trivial matter, as the year is not commensurable with the day, and is not a constant. There are several possible definitions available for the year, such as Julian, Mayan, Gregorian [1], Tropical (or Solar) and Sidereal. It is desirable that the chosen definition be stable with respect to long-term mismatch, i.e., it should contain a term accounting for variations of the year over time. None of the existing definitions of the annus fully embodies this fundamental principle. Definitions of the annus that are based on an intermediate relationship via the day, such as the Julian and Gregorian year, bear an inherent, pre-programmed obsolescence because of the variability of Earth's orbital movement.

Prior to the introduction of the atomic standard to define the second in 1967 (and the subsequent refinement in 1997, see ref. [5]), the SI definition of the second derived in terms of a fraction of a tropical year, for the epoch 1900.0, was "the second is the fraction 1/31 556 925.9747 of the tropical year for 1900 January 1 at 12 hours ephemeris time [6]".

In view of the necessity to define units for time in such a way that they can be considered as constant for practical purposes, it is here recommended to define the year directly on the basis of the SI unit, the second. The Task Group proposes the annus as a defined multiple of the second that minimizes time-dependent inaccuracy. The present recommendation effectively reverses the definition used by [6] in favor of a more precise and up-to-date definition of the second. Taking into account the non-relativistic estimate of astronomical decrease by 0.530 s per century [1], for the epoch 2000.0 the year amounts to 31 556 925.445 s.

The unit a can be supplemented with prefixes k ($\times 10^3$), M ($\times 10^6$), and G ($\times 10^9$), without a full-stop between the prefix and the unit, viz. ka, Ma, and Ga to designate thousand, million, and billion (USA usage) years, respectively. These derived units are already in widespread use in earth and planetary science literature, though as noted above they lack precise definition. The departure lies in the use of different units (e.g., m.y., from the American Engineering Society) for ages and time differences, such that the interval between 90 and 100 Ma, for example, is sometimes designated as 10 m.y. Instead, following quantity calculus [4], units must follow algebraic rules such as the distributive law: 100 Ma – 90 Ma = (100 – 90) Ma = 10 Ma, and so on. Similarly, half-lives should be expressed in ka, Ma, or Ga, and decay constants and rates of geological processes in ka^{-1}, Ma^{-1}, or Ga^{-1}. The definition of the second, and of the year based on the second, is that of a duration, or time interval. All time measurements are performed with respect to some reference datum, and the semantic distinction between age and duration depends solely on the choice of datum. Therefore, both should have the same units, and specification of the reference datum should be embodied in the context rather than in a distinct unit. In other words, in order to express an age, or absolute time, the same unit must be used as for time duration, with the optional addition of qualifiers such as "ago" or "before present" if a disambiguation is required. In such cases, it is implicit that the reference datum is the time of measurement, or a conventional datum such as 1950.0 or 2000.0. Analogies on the use of absolute and relative SI units are useful; for example, it is rarely denied that the depth difference between 100 and 200 m below ground level in a borehole is 100 m.

It is therefore recommended that geoscientists no longer express time durations in distinct ad hoc units such as k.y., M.y., or G.y. The goal is achieving compliance with the international standard by expressing time durations as a, ka, Ma, Ga.

MEMBERSHIP OF SPONSORING BODIES

Membership of the IUPAC Analytical Chemistry Division Committee for the period 2008–2009 was as follows:

President**:** A. Fajgelj (Slovenia); ***Vice President*****:** W. Lund (Norway); ***Secretary*****:** D. B. Hibbert (Australia); ***Past President*****:** R. Lobinski (France); ***Titular Members*****:** M. F. Camões (Portugal); Z. Chai (China); P. De Bièvre (Belgium); J. Labuda (Slovakia); Z. Mester (Canada); S. Motomizu (Japan); ***Associate Members*****:** P. De Zorzi (Italy); A. Felinger (Hungary); M. Jarosz (Poland); D. E. Knox (USA); P. Minkkinen (Finland); J. M. M. Pingarrón (Spain); ***National Representatives*****:** S. K. Aggarwal (India); R. Apak (Turkey); M. S. Iqbal (Pakistan); H. Kim (Korea); T. A. Maryutina (Russia); R. M. Smith (UK); N. Trendafilova (Bulgaria); ***Provisional Member*****:** N. Torto (Botswana).

Membership of the IUPAC Inorganic Chemistry Division Committee for the period 2008–2009 was as follows:

President**:** K. Tatsumi (Japan); ***Vice President*****:** R. D. Loss (Australia); ***Secretary*****:** L. V. Interrante (USA); ***Past President*****:** A. R. West (UK); ***Titular Members*****:** T. B. Coplen (USA); T. Ding (China/Beijing); J. García-Martínez (Spain); M. Leskelä (Finland); L. A. Oro (Spain); J. Reedijk (Netherlands); M. P. Suh (Korea); ***Associate Members*****:** A. V. Chadwick (UK); M. Drábik (Slovakia); N. E. Holden (USA); S. Mathur (Germany); K. Sakai (Japan); J. Takats (Canada); ***National Representatives*****:** T. V. Basova (Russia); A. Bologna Alles (Uruguay); R. Gonfiantini (Italy); P. Karen (Norway); L.-K. Liu (China/Taipei); L. R. Öhrström (Sweden).

Membership of the IUGS Executive Committee is as follows:

President**:** A. C. Riccardi (Argentina); ***Secretary General*****:** P. Bobrowsky (Canada); ***Treasurer*****:** W. Cavazza (Italy); ***Past President*****:** H. Zhang (China); ***Vice Presidents*****:** J. Charvet (France), O. Gerel (Mongolia); ***Councillors*****:** E. Errami (Morocco), C. Simpson (Australia), W. Hill (USA), S. K. Tandon (India).

Membership of the Joint IUPAC–IUGS Task Group on Isotope Data in Geosciences for the period 2006–2009 was as follows: M. L. Bonardi, P. De Bièvre, A. Fajgelj (IUPAC, International Atomic Energy Agency, Vienna, Austria), N. E. Holden, D. Y. Liu (IUGS, Beijing Shrimp Laboratory, Beijing, China), P. R. Renne, I. M. Villa.

ACKNOWLEDGMENTS

Helpful discussions with Prof. Ian M. Mills and comments by N. Christie-Blick, L. E. Edwards, F. Oberli, A. J. Thor, J. Zabicky, 13 unnamed referees, and the editorial input by J. W. Lorimer are gratefully acknowledged.

REFERENCES

1. IUPAC. *Quantities, Units and Symbols in Physical Chemistry*, 3rd ed. (the “Green Book”). Prepared for publication by E. R. Cohen, T. Cvitaš, J. G. Frey, B. Holmström, K. Kuchitsu, R. Marquardt, I. Mills, F. Pavese, M. Quack, J. Stohner, H. L. Strauss, M. Takami, A. J. Thor, p. 137, RSC Publishing, Cambridge, UK (2007).
2. IUPAP. *Symbols, Units and Nomenclature and Fundamental Constants in Physics*, <http://metrology.wordpress.com/measurement-process-index/iupap-red-book/>.
3. Recommendations concerning Units. Reprinted from the “IAU Style Manual” by G. A. Wilkinson, Comm. 5, in IAU Transactions XXB (1987). <http://www.iau.org/science/publications/proceedings_rules/units/>

4. A. Thompson, B. N. Taylor. *Special Publication 811: Guide for the Use of the International System of Units (SI)*, National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA (2008).
5. BIPM. *Le Système international d'unités – The International System of Units SI*, 8th ed., Bureau International des Poids et Mesures, Geneva (2006). <http://www.bipm.fr/fr/si/si_brochure/>
6. The 11th General Conference on Weights and Measures (GGPM), Resolution 9; CR 86 (1960).