International Union of Geological Sciences
International Commission on Stratigraphy

International Subcommission on Stratigraphic Classification
ISSC

http://users.unimi.it/issc

Chair **Brian Pratt**
brian.pratt@usask.ca

Vice Chairs **Helmut Weissert**
helmut.weissert@erdw.ethz.ch

Jan Zalasiewicz
Jaz1@leicester.ac.uk

Secretary **Maria Rose Petrizzo**
mrose.petrizzo@unimi.it

NEWSLETTER N. 15

September 2009

Edited by M.R. Petrizzo

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1. EDITORIAL

Dear colleagues:

The first half of 2009 looked like it was going to be a fairly quiet interlude for ISSC. Cor Langeris and colleagues first circulated and then submitted their chapter on Magnetostratigraphy. Thanks to all those who sent them comments to what is really a very fine manuscript. Indeed, I think the fact that there were so few comments shows that the authors did a truly superlative job—bravo! You know, science is unpredictable: who would have thought that not a few months later I would find myself, a lowly paleontologist and sedimentologist, dabbling in… magnetostratigraphy! One of the samples our PhD student collected from the Early Cambrian of the southern Rocky Mountains may retain a primary pole, according to Vadim Kravchinsky of the University of Alberta who did the analysis. I think that is one of the lessons we learn when we tackle Stratigraphy: trying to understand the geological past leads us down many unexpected paths.

On the other hand, the past few months could not have been more exciting for the ISC. With Stan Finney at the helm, it saw the base of the Jurassic (base of the Hettangian) proposed, voted on, and ratified. This was a straightforward situation that was decided upon almost unanimously after a great deal of high-quality data was assembled. A short description is included in this Newsletter.

At the same time, voting members of ICS also considered a combined proposal dealing with the base of the Pleistocene, retention of the Quaternary and definition of the Neogene. As would be obvious to anyone who attended last year's evening discussion at the IGC in Oslo or followed the issues on websites, e-mail, and in print, this was a far more controversial subject. The results are also summarized.

Just when Maria Rose and I were ready to assemble a nice short Newsletter with almost no other news, all hell broke loose in the North American Commission of Stratigraphic Nomenclature. Please read the story I have put together plus the various accompanying documents. Is this an important issue or not? Nonetheless, it will soon come to the attention of ISSC and ISC. Readers should be aware that NACSN was the inspiration for ISSC, and the North American Stratigraphic Code served as the template for the International Stratigraphic Guide, as well as numerous national stratigraphic codes. But, stratigraphy and stratigraphic nomenclature are international in scope. Thus, what transpires with one national commission or committee has implications for all. I am very grateful to Lucy Edwards and Nick Christie-Blick for reading over my essay and keeping me true.

In the meantime, the working groups on Lithostratigraphy, Biostratigraphy, Chronostratigraphy and Sequence Stratigraphy are beavering away on their chapters. Let us all plan to have these submitted early in 2010!

Brian Pratt

ISSC chair

Saskatoon, September 2009

2. GEOLOGICAL TIME UNITS

2.1 The notation for Geological Time: confused concepts or a tempest-in-a-teapot?

In late April, Nick Christie-Blick was participating in a Ph.D. defence at the American Museum of Natural History and it came up, as he reported immediately to Lucy Edwards of the USGS and doyenne of the NACSN, that “the SI unit Ma (and presumably ka and Ga) is about to change its meaning to a duration as well as an age. For as long as I can remember, we have been careful about distinguishing Ga, Ma and ka (ages in billions, millions and thousands of years) from Gy, My, m.y. and ky for spans of time.” This was the first Lucy had heard about such a trend. At the same time, she was seeing copy-edits from several manuscripts she had written and co-authored for a special paper of the Geological Society of America. First, she reminded Nick that years were not part of the SI, as the SI unit for time is the second. Then both she and Nick started asking questions. Upon investigation, she discovered that there had been an unannounced change in the instructions to the copy editors of GSA publications. On the one hand, the GSA website steers authors towards the NACSN’s North American Code of Stratigraphic Nomenclature and/or ISSC’s International Stratigraphic Guide—which, thankfully, are basically the same instructions found in just about every geological journal. In many editions the Code has urged the abbreviation ‘a’ for *annum* [i.e. *annus* in the nominative singular case] and ‘y’ for year to denote, respectively, geochemically measured points in geological time (geochronology) and estimated spans of geological time, as in Ma versus My (Myr is suggested in the AGI Glossary of Geology). For us the K–T boundary occurred at 65.5 Ma, and the Maastrichtian before it lasted some 10 My. On the other hand, however, GSA as well as AGU and some other journals were telling authors to no longer use a different notation to distinguish what the stratigraphic community has long considered to be two fundamentally different concepts. *Annus* was the order of the day. How did this change come about with nobody in NACSN or ISSC being asked for comment?

After a little bit of sleuthing, Lucy turned up a letter-to-the-edtitor to *GSA Today* back in 2004 from the co-chairs of an IUGS Working Group on Decay Constants in Geochronology.

Letter. . . . .

Send letters to *GSA Today*, P.O. Box 9140, Boulder, CO 80301-9140, USA, or to jhammann@geosociety.org. Please keep your letter to 300 words or fewer. *GSA Today* reserves the right to edit for length and/or to publish letters online at www.geosociety.org/pubs/.

Dear Editor,

We write to encourage GSA journals to conform to the Sisteme International (SI) regarding units of time. The SI unit of time, the second (s), is impractical for earth scientists, astronomers and nuclear physicists alike. In such cases, the SI tolerates other units, and for geological applications the annum (a) is used, where $1\ a = 3.16 \times 10^7\ s$ (Holden, 2001). As with other units, thousands, millions, and billions of these are appropriately designated ka, Ma, and Ga, respectively. So far, so good—these derived units are in widespread use in earth science literature. The departure lies in the use of different units (e.g., m.y.) for time differences such that the interval between 90 Ma and 100 Ma, for example, would be designated as 10 m.y. in, e.g., *Geology*. Following correct SI usage (Nelson, 2002) units must follow algebraic rules such as the distributive law: 100 Ma – 90 Ma = (100 – 90)Ma = 10 Ma, and so on. Similarly, rates and decay constants should be expressed in $(ka)^{-1}$, $(Ma)^{-1}$ or $(Ga)^{-1}$. Analogies are useful: we would all agree that the interval between 100 m and 200 m depths in a borehole is 100 m, or that a magma at 1000 °C is 100 °C hotter than one at 900 °C. Why should we treat time units any differently? We urge GSA to abandon the policy of expressing time differences in k.y., m.y., or g.y., and thereby achieve compliance with the SI standard.

Sincerely,
Paul R. Renne and Igor M. Villa, co-chairs
IUGS Working Group on Decay Constants in Geochronology

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This letter received only a few responses and was essentially overlooked by members of NACSN. This working group seems to have expanded its base by bringing the International Union of Pure and Applied Chemistry as its co-sponsor, which of course is not unreasonable given the nature of the subject matter. However, in 2007 the now re-named IUPAC–IUGS Task Group on Isotope Data in the Geosciences went ahead and contacted a number of society publications committees and editors of geoscientific journals with the urging that a single nomenclature for numerically expressed geological time should be preferred. The rationale was that this would be more in line with the kinds of units recognized by the Système International d'Unités. A number of these journals quietly adopted the recommendation, even though not all editors agreed with it, notably the co-editors of *Paleoceanography* which is published under the auspices of the AGU. Noteworthy, however, was the fact that their recommendation turned out not to have been vetted beforehand by the executive committee of IUGS. (Whether the IUPAC similarly demands that all recommendations from working groups under its auspices to be sanctioned by its executive committee [if there is one] is unclear to me.)

Earlier this year, the task group submitted its recommendation formally to IUPAC's journal, *Pure and Applied Chemistry*. Lucy alerted members of NACSN and other interested parties to their manuscript and there occurred a spirited (but, I stress, always collegial) exchange between various NACSN members and the co-chairs of the Task Group, Igor Villa and Paul Renne. Formal comments to the manuscript were submitted to the journal, in the manner of peer reviews. Several members of NACSN did a great deal of searching through the literature to discover that there is quite a history to how geoscientists have dealt with the issue of denoting geological time, that goes back to the early days of geochronology. Nick prepared a concise statement of the principal objections to the recommendation and sent it to GSA; Igor and Paul, on behalf of the task group, responded to Nick's points. Nick was then invited to review their revised manuscript for the journal and was naturally critical of both the recommendation and modus operandi. Lucy and a host of others (including just about all the members of NACSN that she could get in touch with), submitted a petition to the council of GSA, asking that formal adoption of the task group's recommendation be delayed pending further discussion and input from NACSN and any other interested parties. Being also a member of council I had to abstain, but I can report that it voted to accept NACSN's request. The line beginning "Annum (a) is used to denote year as a unit of measure. . ." has recently disappeared from the AGU online Style Guide for Authors. Meanwhile, Marie-Pierre Aubry and other members of NACSN have prepared a short paper for submission to a fortuitously timed special issue of *Stratigraphy*, devoted to stratigraphic nomenclature. This provides more detail and history behind the objections to the task group's recommendation. Nick will be submitting an essay to *GSA Today* shortly.

At the same time, as chair of ISSC, I asked Alberto Riccardi, president of IUGS, for information on the status of the task group's recommendation. Because the executive committee of IUGS has not yet received a final report from the task group, Alberto asked the task group to remove the IUGS moniker from the recommendation until, and if, it is officially sanctioned. Of course that process means that the executive committee will solicit views of its component organizations, especially ICS. For that reason, readers of this newsletter should start thinking about the issue.

This has been an interesting experience. Scientific ideas flowed freely and were debated vigorously as they should. The passion the subject aroused might be hard to explain to those to whom the argument may seem just about an abbreviation (Why 'y' or 'a', eh?). To others it reflects the conceptual difference between durations of geological time and points in geological time, and because one of the goals of a scientific paper should always be maximum clarity, the distinction is worth maintaining. SI units are necessary in science where measurement is involved, but geology does not always fit the template of physics and chemistry. (This may be one of the reasons why we are geoscientists!)

This has been interesting in another aspect. I am a member of NACSN and also chair of ISSC. Both have similar scientfic philosophies and mandates, and it should be expected that members of both groups appear publicly like-minded on stratigraphic methods and concepts—after all, these are fundamental to geology. Similarly, when voting members of ICS make a final decision about a GSSP, that decision should be accepted by everyone including those in the minority who may have voted against it. Committees of any organization need to be sure that their views truly represent the consensus of the members with respect to factual material, and be cognizant of issues that are still the subject of debate. Scientific organizations, be they royal or national societies or discipline-specific groups, have to be careful to what pronouncements they lend their name. Grassroots initiatives work better than top-down directives.

Brian Pratt

2.2 IUPAC-IUGS TASK GROUP on Isotope Data in Geosciences

Convention on the use of SI units in Earth Sciences

International Union of
Pure and Applied Chemistry

Convention on the Use of Units for Time in Earth and Planetary Sciences

Journal:	*Pure and Applied Chemistry*
Manuscript ID:	PAC-REC-09-01-22
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Complete List of Authors:	Villa, Igor Holden, Norman; Brookhaven National Laboratory De Bièvre, Paul Renne, Paul; Berkeley Geochronology Center
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INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY
and
INTERNATIONAL UNION OF GEOLOGICAL SCIENCES

JOINT IUPAC-IUGS TASK GROUP ON ISOTOPE DATA IN GEOSCIENCES‡

CONVENTION ON THE USE OF UNITS FOR TIME IN EARTH AND PLANETARY SCIENCES

(IUPAC-IUGS RECOMMENDATIONS 200X)

Prepared for publication by:
N. E. HOLDEN[1,3], P. DE BIÈVRE[1,4], P. R. RENNE[2,5] and I. M. VILLA[2,6,*]

‡ Membership of the Task Group for the period 2006-2009 is as follows: M. BONARDI (IUPAC, LASA, Università degli Studi di Milano, Italy), 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

[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] Consultant on Metrology in Chemistry, Duineneind 9, B-2460 Kasterlee, Belgium; [5]Berkeley Geochronology Center, 2455 Ridge Road, Berkeley, CA 94720, USA; [6]Institut für Geologie, Universität Bern, CH-3012 Bern, Switzerland.
*Corresponding author; E-mail: igor@geo.unibe.ch

Convention on the Use of Units for Time in Earth and Planetary Sciences

(IUPAC-IUGS Recommendations 200x)

Abstract: The units of time (both absolute time and duration) most practical to use in Earth and Planetary Sciences are multiples of the year, or annus (a). Its proposed definition in terms of the fundamental SI unit for time, the second (s), for the epoch 2000.0 is 1 a = 3.1556925445×10^7 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 the SI standard regarding 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.

SI AND NON-SI UNITS FOR TIME

The SI unit of time, the second (s), is impractical for earth scientists and nuclear physicists alike. In such cases the SI tolerates other units. For geological applications and for use with long-lived radioactive nuclides the year, or annus (symbol, a), is used [1,2].

The definition of the year in terms of the fundamental SI 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, Gregorian, Tropical (or Solar) and Sidereal. Prior to the introduction of the atomic standard to define the second in 1967, SI used a definition of the second derived in terms of a fraction of a tropical year, for the epoch 1900.0, as "the second is the fraction 1/31556925.9747 of the tropical year for 1900 January 0 at 12 hours ephemeris time [3]".

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 re-define the year on the basis of the second recommended at present by [4], effectively reversing the definition used by [3] in favour of a more precise and up-to-date definition of the second. Taking into account the astronomical decrease by 0.530 s per century, for the epoch 2000.0 the year amounts to 31556925.445 seconds.

As with other units, thousands, millions and billions of these are appropriately designated ka, Ma, and Ga, 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 Ma and 100 Ma, for example, is sometimes designated as 10 m.y. Instead, following correct SI usage [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 rates and decay constants 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. In order to express an age, or absolute time, the same units must be used, with the optional addition of qualifiers such as "ago" or "before present" if a disambiguation is required. Analogies on the use of absolute and relative SI units are useful: it is rarely denied that the depth difference between 100 m and 200 m below ground level in a borehole is 100 m.

It is therefore recommended that geoscientists abandon the incorrect habit of expressing time durations in distinct *ad hoc* units such as k.y., M.y., or G.y. The correct way to achieve compliance with the SI standard is expressing time durations as a, ka, Ma, Ga. When age units in geochronology are followed by the abbreviation "BP" (before present), "present" refers to a particular datum such as that of calendar year 1950.0 widely used in radiocarbon dating. As this nomenclature refers to a datum, and not to the units themselves, no recommendation is made for change in usage at this time.

ACKNOWLEDGEMENT

Helpful discussions with Prof. Ian M. Mills are gratefully acknowledged.

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2.3 Objections to the joint IUPAC-IUGS TASK GROUP recommendation by Christie-Blick

June 26, 2009

The Joint IUPAC-IUGS Task Group On Isotope Data In Geosciences has made a provisional recommendation for a Convention on the Use of Units for Time in Earth and Planetary Sciences [1].

"The units of time (both absolute time and duration) most practical to use in Earth and Planetary Sciences are multiples of the year, or annus (a). Its proposed definition in terms of the fundamental SI unit for time, the second (s), for the epoch 2000.0 is $1\ a = 3.1556925445 \times 10^7\ s$. 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 the SI standard regarding units of time" [1,2].

I object strongly to two elements of the proposed convention and to the Geological Society of America's premature adoption of them. The first is the choice of annus (a) as the unit. That symbol has been used widely and for more than three decades in the Earth science literature for points in geological time (dates) and for the ages of sediments, rocks or events corresponding to those points in time [3,4,5]. Most commonly, this is in the form of ka, Ma, and Ga, for thousands, millions and billions of years before present, and with the calendar year 1950 providing a widely accepted datum for specifying the "present." My second objection is to the proposed formal abandonment of the practice of carefully distinguishing between ages and spans of time [4,5,6]. The symbols ka, Ma and Ga are explicitly not applicable to the latter.

With this document I seek an immediate moratorium on the application of the Joint IUPAC-IUGS Task Group's as yet unpublished recommendation in all publications of the Geological Society of America until a full and proper discussion of the issue can be completed. I also propose workable alternative symbols for year as a unit of time and for multiples of that unit (yr, kyr, Myr, Gyr). As far as I can determine, these symbols present no conflict with prior usage.

The distinction between points in geological time and spans of time is useful – some would say necessary. For those engaged in the study of Earth's history and in the establishment of a geological timescale, 90 Ma and 100 Ma refer to specific datums in the Cretaceous Period. The 10 million year interval between those datums is not written as 10 Ma because that invites immediate confusion with a different datum, in the Miocene Epoch. While it is true that careful writing and design of illustrations might achieve the same objective, to change a widely employed, workable convention or to require newly cumbersome language represents a disservice to the scientific community.

The Joint IUPAC-IUGS Task Group provides no compelling rationale for the proposed change. The Task Group asserts that for correct SI usage, "units must follow algebraic rules such as the distributive law: 100 Ma – 90 Ma = (100 – 90) Ma = 10 Ma, and so on." However, if 100 Ma and 90 Ma refer to geological datums, it is not necessary for them to follow algebraic rules even if time in millions of years before present is the manner in which a datum is specified. Earth science makes use of all manner of scales (paleontological, magnetopolarity, isotope-based, and so forth) that are fundamental to the discipline, not about to be abandoned, and not subject to SI conventions. The Task Group is intent on fixing a problem that does not exist.

Another difficulty concerns the supposed inviolability of algebraic rules such as the distributive law. In the Task Group's example, differences in ages (durations) must have the same units as ages. I note, however, that the unit of Celsius temperature (°C) is by definition equal in magnitude to the kelvin (K) [2, p. 114]. The Celsius scale differs only in its reference temperature. Yet a different symbol is acceptable for this purpose because it has proven useful for practicing scientists. So even if we set aside the argument that datums and spans of time are conceptually different, a precedent exists for offset parallel scales.

It has been asserted that the convention by which ka, Ma and Ga refer to points in geological time has not been universally accepted. That is both true and irrelevant. It is true to the extent that some individuals, journals or organizations have consciously, or because they were unaware of the convention, chosen to use these symbols for spans of time. It is irrelevant because the community that has consistently applied ka, Ma and Ga in a more specific sense is hardly inconsequential to the conduct of international science. Priority has a bearing in this case. As important, it is not necessary to introduce confusion where none currently exists because other symbols are available.

I agree with the Joint IUPAC-IUGS Task Group that it is appropriate to abandon such informal abbreviations and symbols as m.y, b.y., k.y., M.y., G.y., y, ky, my, My, Gy and so on because, while they have served Earth science well, they suffer from inconsistencies and a conflict with an existing SI unit. The abbreviations m.y. and b.y. can be defended for millions and billions of years as correct English, with periods denoting the foreshortening of the words millions, billions and years. In this case, m is specifically not an SI prefix (milli). However, k.y., M.y. and G.y., though formatted in a similar way, are poor choices because k, M and G *are* SI prefixes. So periods are not required. The difficulty with Gy, My, ky and y is that Gy is already a symbol for an SI derived unit for absorbed energy (gray), where Gy stands for J/kg or m^2 s^{-2} [2, p. 118]. If Gy is not available for billions of years, on the basis of priority, then for reasons of consistency, My, ky and y ought not to be used either. The symbol my is incorrect because in the absence of periods it implies 10^{-3} years and not the intended 10^6 years. In light of these considerations, I favor a single remaining option.

Adoption of yr as the symbol for year, with kyr, Myr and Gyr denoting thousands, millions and billions of years, and preservation of a, ka, Ma, and Ga specifically for datums in geological time provides a workable compromise. Individuals, journals and organizations may then choose to use yr, etc. for both ages and spans of time, in the manner advocated by the Task Group. Others will prefer to differentiate geological datums from spans of time in the manner defended here, and – as I have noted – without contravening SI conventions. I urge the Geological Society of America to return to earlier practice in that regard.

Adoption by the Council of the Geological Society of America of a, ka, Ma and Ga as the only acceptable time units in GSA publications (April, 2007) did nothing to advance the GSA's stated publication policy on the use of SI units. Years are not SI units, no matter what symbols are selected; spans of time already conform with algebraic rules; and the establishment of geological datums falls outside the purview of the International System of Units. While abbreviations such as m.y., M.y., k.y. and G.y. ought to be replaced with a consistent set of symbols, following appropriate discussion, that is a relatively trivial different issue.

ACKNOWLEDGMENTS

Helpful email exchanges with Paul Renne, Igor Villa, Lucy Edwards, Marie-Pierre Aubry, William Berggren, John Van Couvering, Brian Pratt and other members of the North American Commission on Stratigraphic Nomenclature are gratefully acknowledged.

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Nicholas Christie-Blick
Department of Earth and Environmental Sciences and
Lamont-Doherty Earth Observatory of Columbia University
Palisades, New York 10964-8000, USA

2.4 Replay by the joint JOINT IUPAC-IUGS TASK GROUP recommendations to Christie-Blick

29 June, 2009

Dear Colleagues,

This is in reply to the manifesto of June 26, 2009 by Nicholas Christie-Blick entitled "Objections to the Joint IUPAC-IUGS Task Group Recommendations".

The task group met on June 17-18 in Bern, Switzerland and considered among other topics the objections raised by Prof. Christie-Blick and some of his colleagues, which had already been communicated to some of us in numerous (and largely repetitive) emails.

The issue can be distilled to the fundamental question of whether two sets of units should be employed for time, one referring to "absolute" time and one referring to time differences. There is neither precedent nor provision in the SI for this. The example cited by Prof. Christie-Blick, of the parallel units °C and K for temperature, fails to support his case because in both instances the same unit is used for a temperature (relative to a benchmark, the freezing point of water or zero thermal energy, respectively) and differences between two such temperatures. Both applications carry the same units, either °C or K. These are two different quantity scales, albeit carefully defined for interchangeability, but not different conventions regarding units of absolute versus differential intervals of time. The SI system is especially suited if quantities of different kind are present in the same measurement model.

Moreover, let us be clear that time and time intervals are not really distinct in the Earth and Planetary Sciences. When we determine a radioisotopic age, the resulting age is intrinsically relative to the time of measurement. Derivative time scales, such as those based on geomagnetic polarity changes, biotic evolutionary events, marine isotopic variations, or whatever, are also intrinsically relative because they are calibrated by radioisotopic ages. Inevitably, the radioisotopic ages used to calibrate these phenomenological time scales were determined at different times over the past half- century or so, thus there is inherent variation at the ca. 50 annus level in virtually all such time scales.

Fortunately, for nearly all geological applications, the uncertainty inherent to this variable benchmark is beneath the detection limits of relevant geochronometers. If such timescales persist for longer than a few hundred years, and if –as seems improbable- century plus vintage data retain their relevance, then consideration of the variable benchmark may become important. In any case, if we want to be strictly correct then it suffices to acknowledge that nearly all radioisotopic ages[1] are referred to the time of measurement of the relevant radioisotopes. Whether or not this time stamp is published along with the data, or otherwise recorded for posterity, is another matter but this is of relative insignificance as we are referring to philosophy rather than pragmatism.

Having clearly established that only one derived time unit (and its order of magnitude multiples k, M and G) is logical and SI-consistent, what should it be? Prof. Christie-Blick states:

> *"Adoption of yr as the symbol for year, with kyr, Myr and Gyr denoting thousands, millions and billions of years, and preservation of a, ka, Ma, and Ga specifically for datums in geological time provides a workable compromise. Individuals, journals and organizations may then choose to use yr, etc. for both ages and spans of time, in the manner advocated by the Task Group. Others will prefer to differentiate geological datums from spans of time in the manner defended here, and – as I have noted – without contravening SI conventions."*

As previously noted, there are really no such things as "datums in geological time" except relative to time of measurement or some arbitrarily defined benchmark, so this aspect of the argument is specious. We recommend the annus due to ample precedent (see references in our recommendation) and existing usage by ISO, BIPM, IUPAP, IUPAC and IAU among other organizations. We see no need to introduce yet another unit when in fact the clear course of action is to eliminate several superfluous ones (m.y., Myr, etc).

The Task Group undertook consideration of this matter in order to promote common language (perhaps "concepts", in the sense of a metrologically well-defined entities andassociated measuring procedures, is a better term) between different scientific disciplines.
If the Earth and Planetary Sciences - which so pervasively embody the applications of chemistry and physics - wish to embrace membership in the larger community of science, and adhere to conventions such as the SI, our recommendation would seem to be sound.

Sincerely,

Paul R. Renne (Chair)
Paul de Bievre
Mauro Bonardi
Igor M. Villa
Joint IUPAC-IUGS Task Group[2] on Isotope Data in Geosciences

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[1]Exceptions being those few ages (e.g. radiocarbon) that are benchmarked to a particular time (e.g., 1950 owing to the "bomb-spike" in radionuclides).

[2] *A fifth member of the Task Group (Norman E. Holden) who participated in the Bern meeting is not listed as a signatory to this letter because he was incommunicado at the time of internal review and thus unable to contribute to it. It is our informed belief, based on discussions in Bern, that he shares the views presented here.*

2.5 Response to PAUL RENNE concerning recommendation of the Joint IUPAC-IUGS Task Group On Isotope Data In Geosciences by Christie-Blick

June 30, 2009

I appreciate Paul Renne's rapid response to my June 26, 2009 memo to GSA editors and council. I reply below. However, this is not the forum in which this discussion should be taking place.

The fact that there is any debate at all – and there has been a great deal since word leaked out – indicates only that the original decision by the council was premature. A graceful way forward at this juncture will be for GSA to delay implementation of the new policy until after the matter can be properly evaluated. Indeed, any other outcome will be a disservice to GSA membership.

The central issue relates to conventions for communicating Earth science. Conventions are a matter of choice, not discovery, and they ought to reflect the varied interests of the many constituencies involved. While it is useful to establish rules that apply as far as possible across the sciences – and the International System of Units (SI) provides a mechanism for accomplishing that – it is also the case that each scientific discipline inevitably develops its own culture. Earth science and astronomy, for example, are distinctive because they involve large physical and temporal scales and an important historical dimension. For geologists, time is more than the x-axis for the output of some laboratory experiment. It is also a series of benchmarks in Earth history. The practice of carefully distinguishing those benchmarks from unconstrained spans of time has been accepted for a long time because it has proven vital in communication, and it ought not to be abandoned without due consideration and a compelling rationale.

Remarkably, the Joint IUPAC-IUGS Task Group's argument boils down to a seemingly trivial observation. SI units follow algebraic rules such as the distributive law, in which differences in some quantity are expressed in the same units as the quantity. Therefore, the Task Group insists, there can be only one measure of time, and one set of units for expressing time. So the profession of Earth science must decide: Is it more important to maintain a useful distinction between geological datums and spans of time? Or is it more important to adopt a concept of time that works best in non-historical sciences? I hesitated to include a comparison with the °C and kelvin temperature scales because the analogy works primarily as an example of a quantity that involves two SI scales. However, if you go to the pages quoted in my "objections" document, you will find an equation in which Celsius temperature (on the left) is expressed in terms of kelvin (on the right). A similar equation can be written relating ages in Ma to spans of time in whatever symbol you chose. However, the more persuasive argument, in my view, is that the specification of geological datums is simply outside the context for which SI was developed.

As Lucy Edwards points out in her June 29, 2009 communication on behalf of the North American Commission on Stratigraphic Nomenclature, geological time is formally outside SI for another reason: The SI unit for time is the second. It seems fair to ask, therefore, why units not governed by SI conventions need to adhere to SI conventions – though this is not a general issue on which I hold a strong opinion. The intent of the Task Group is also unclear. Is the goal to establish what is known formally as an "SI derived unit" (Paul Renne's response, top of page two)? Or is the goal instead to specify a "non-SI unit accepted for use with SI?" The minute, hour and day are examples of the latter. In its draft recommendations, the Task Group offers the following statements under the heading "SI and Non-SI Units for Time:" "The SI unit for time, the second (s), is impractical for earth scientists and nuclear physicists alike. In such cases, the SI tolerates other units" (my italics). Were the intent to establish an SI derived unit, in the manner implied by Prof. Renne, the Task Group would face a substantially more difficult challenge. According to standard procedure, "derived units are products of powers of base units" – the second in this case. The year cannot be specified in this way. I do not think that it is possible to achieve "compliance" with SI through selective application of SI rules.

The bottom line is this. Reaching an interdisciplinary consensus on a non-SI unit for time is a worthy goal. It is clear that the year has been used informally and according to more than one definition (check the International Astronomical Union website, for example), and with numerous abbreviations/symbols. So if we can agree on the value of distinguishing geological datums and spans of time – and even if we can't – the task at hand is primarily one of deciding upon the duration of a year and on the symbol to be used. No-one is forcing Paul Renne and colleagues to acknowledge the significance of points in geological time. The quest for the earliest use of 'a' is also not likely to be productive, though I note that Ga, Ma and ka were already in wide use for geological ages when I was a graduate student (1974-79). A more sensible approach may be to defer to the discipline – Earth science – for which the symbols Ga, Ma and ka have been of fundamental significance. I do not understand why it is so hard to imagine 'yr' as a consistently defined non-SI unit for time. The question for Prof. Renne and colleagues is whether they are prepared to accept the compromises that will be required to forge the consensus that I suspect is readily achievable.

2.6 NACSN Resolution

Whereas
GSA publication policy is to use "the International System (SI) units in text, illustrations, and captions."

<verbatim quote from Publications Committee Chair>In April, 2007, Council of the Geological Society of America approved the International Union of Pure and Applied Chemistry (IUPAC) and the International Union of Geological Sciences (IUGS) task group "Recommendations for isotope data in the geosciences." The recommendation states that "geoscientists abandon the habit of expressing time differences in k.y., M.y., or G.y., and thereby achieve compliance with the SI standard." The consequence of this is that the only accepted time units in GSA Publications are a, ka, Ma, and Ga. <end quote>

This council action is in direct contradiction with the first sentence above. Years are not SI units.

The only SI unit for time is the second. No one is proposing that we abandon the use of years and resort to seconds only. Similarly, as years are not SI units, there is no “SI standard” for them.

This council action is also in direct contradiction with the International Stratigraphic Guide and the North American Stratigraphic Code.

The IUPAC-IUGS task group has a somewhat different provisional recommendation (http://www.iupac.org/web/ins/2006-016-1-200) now out for prepublication comment. No publication or official action has resulted.

We, the undersigned, respectfully request that
GSA publications reconsider the action of April 2007, and continue to allow the use of Ga, Ma, ka for time before the present, together with suitable abbreviations (perhaps Gyr, Myr, kyr, yr, My, ky, and m.y., as appropriate) for time durations, until the matter is resolved.

Signed,
Lucy E. Edwards, U.S. Geological Survey, NACSN (North American Commission on Stratigraphic Nomenclature
Elmer A Bettis, III, University of Iowa, GSA Representative to NACSN
Brian R. Pratt, University of Saskatchewan, GSA Council Member, NACSN
David S. Fullerton, U.S. Geological Survey, NACSN
John A. Van Couvering, Editor in Chief, Micropaleontology Press, NACSN
R. G. Anderson, Geological Survey of Canada, NACSN
J. Wright Horton, Jr., U.S. Geological Survey
Ismael Ferrusquia-Villafranca, Universidad Nacional Autonoma de Mexico, NACSN
Tony Hamblin, Geological Survey of Canada, NACSN
Norman P. Lasca, University of Wisconsin-Milwaukee, NACSN
Jerry Dickens, Rice University, co-editor Paleoceanography
Ed Landing, State Paleontologist, New York State Museum, NACSN
Peter M. Sadler, University of California, Riverside, NACSN
Frank R. Brunton, Ontario Geological Survey, NACSN
Rob Rainbird, Geological Survey of Canada, NACSN
Ricardo Barragán Manzo, Universidad Nacional Autonoma de Mexico, NACSN
Gregory S. Gohn, U.S. Geological Survey
Robert R. Jordan, Professor Emeritus and State Geologist Emeritus, NACSN
Nicholas Christie-Blick, Columbia
Ashton Embry, Geological Survey of Canada, NACSN
Nick Tew, Geological Survey of Alabama, AASG, NACSN
Art Donovan, BP America Gas, NACSN
Jared Morrow, San Diego State, NACSN
Vitor Abreu, ExxonMobil Upstream Research Company, NACSN

EXHIBIT A

The year, or annus, or annum is not a part of the Système international d'unités (International System of Units).

The reference (English version, begins on p. 93) is:
http://www.bipm.org/utils/common/pdf/si_brochure_8_en.pdf

SI units consist of **SI base units** (p. 111) and **SI derived units** (p. 116).
The base unit of time is the second (p. 112).

SI derived units (p. 116) "are products of powers of base units. Coherent derived units are products of powers of base units that include no numerical factor other than 1. The base and coherent derived units of the SI form a coherent set, designated the set of coherent SI units (see 1.4, p. 106)."

There are no SI derived units of time (Table 2, p. 117, Table 3, p. 118).
There are two SI derived units that are both s-1 (p. 118). As explained in footnote (d) "The hertz is used only for periodic phenomena, and the becquerel is used only for stochastic processes in activity referred to a radionuclide."

SI also recognizes **Non-SI units accepted for use with the International System of Units** (Table 6, p. 124). This table includes three units of time: minute, hour, day.

Three additional tables, Table 7 (p. 126, Non-SI units whose values in SI units must be obtained experimentally), Table 8 (p. 127, Other non-SI units), and Table 9 (p. 128, Non-SI units associated with the CGS and the CGS-Gaussian system of units) include exactly two units of time: the natural unit (n.u.) of time, which is given as 1.288 088 6677 (86) × 10−21 s, and the atomic unit of time,which is given as 2.418 884 326 505 (16) × 10−17 s. Both must be obtained experimentally.

Searches of the PDF document for "annus" and "annum" retrieve **0** results.

A search of the PDF document for "year" retrieves the following **15** results.
p. 95 meets every four **year**s. . . meets every **year**.
p. 109 In later **year**s, Gauss and Weber extended these measurements
p. 112 the international prototype is subject to reversible surface contamination that approaches 1 μg per **year** in mass. . . a definition given by the International Astronomical Union based on the tropical **year** 1900.
p. 123, 124, 129 will continue to be used for many **year**s (twice). . . will continue to be true for many **years**.
p. 138, 147, 149 tropical **year** 1900, tropical **year**, tropical **year** for 1900 (twice)
p. 162 at least one year in advance
p. 166 for over thirty **year**s to express catalytic activity. . . in the same year the CGPM invited the International Committee
Q.E.D. The year is not part of the SI. The abbreviations a, ka, Ma, Ga are not part of the SI

EXHIBIT B

Relevant passages in the North American Stratigraphic Code, International Stratigraphic Guide, and Glossary of Geology

Article 13 of the NACSN, remark (c)
Convention and abbreviations. -The age of a stratigraphic unit or the time of a geologic event, as commonly determined by numerical dating or by reference to a calibrated time-scale, may be expressed in years before the present. The unit of time is the modern year as presently recognized worldwide. Recommended (but not mandatory) abbreviations for such ages are SI (International System of Units) multipliers coupled with "a" for annum: ka, Ma, and Ga for kilo- annum (103 years), Mega-annum (106 years), and Giga-annum (109 years), respectively. Use of these terms after the age value follows the convention established in the field of C-14 dating. The "present" refers to 1950 AD, and such qualifiers as "ago" or "before the present" are omitted after the value because measurement of the duration from the present to the past is implicit in the designation. In contrast, the duration of a remote interval of geologic time, as a number of years, should not be expressed by the same symbols. Abbreviations for numbers of years, without reference to the present, are informal (e.g., y or yr for years; my, m.y., or m.yr. for millions of years; and so forth, as preference dictates). For example, boundaries of the Late Cretaceous Epoch currently are calibrated at 63 Ma and 96 Ma, but the interval of time represented by this epoch is 33 m.y.

International Stratigraphic Guide, second edition, p. 16, Definition 12.
"**Geochronometry**. The branch of geochronology that deals with the quantitative (numerical) measurement of geologic time, usually in thousands or millions of years. The abbreviations ka for thousand (103), Ma for million (106) and Ga for billion (milliard or thousand million, 109) years are now generally used to express the length of time before the present (years ago), not the duration of a past geological time interval."

Glossary of Geology, Fifth Edition, p. 259, 386, 347
Ga Giga-annum, one billion (109) years. Informal SI notation, where annum is age in years before present, with "present" fixed as 1950. This term has largely replaced the various abbreviations for "billions of years before present" in geological literature. It is not equivalent to the elapse time interval or duration in "billions of years" (byr).
ka Kilo-annum, one thousand (103) years. Informal SI notation, where annum is age in years before present, with "present" fixed as 1950. This term has largely replaced the various abbreviations for "thousands of years before present" in geological literature. It is not equivalent to the elapse time interval or duration in "thousands of years" (kyr).
Ma Mega-annum, one million (106) years. Informal SI notation, where annum is age in years before present, with "present" fixed as 1950. This term has largely replaced the various abbreviations for "millions of years before present" in geological literature. It is not equivalent to the elapse time interval or duration in "millions of years" (myr).
[no entry for a]

EXHIBIT C

Council action appears to eliminate the well established and long-useful distinction between ages in Ga, Ma, ka, a and intervals of time in GSA publications.

The principal argument for eliminating the distinction is with SI standards. As the year is not an SI unit, this argument fails.

The principal argument for retaining a distinction between dates expressed as ages and quantities of time (durations) is that they are different time concepts. The first refers to specific points in the timescale, whereas the second corresponds to intervals of time between chosen dates, hence both are relevant to the understanding of geologic history.

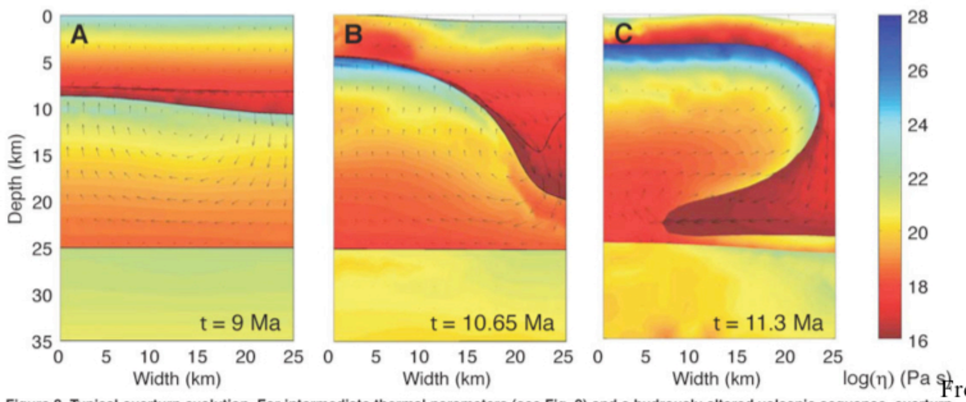
The abandonment of this distinction discourages clarity, encourages confusion, and places unnecessary burden on both readers and authors. To illustrate, look at Figure 3. Is Fig. 3A showing a point in time before or after Figure 3C? What is the age of the material in the figure? Any stratigrapher would say Miocene.

Simultaneous generation of Archean crust and subcratonic roots by vertical tectonics

C.M.I. Robin and R.C. Bailey
Departments of Physics and Geology, University of Toronto, 60 St. George Street, Toronto, Ontario M5R1A7, Canada

ABSTRACT

Archean cratons are characterized by granite-greenstone belts, by abundant tonalites, trondhjemites, and granodiorites (TTGs), and by the presence of strong and buoyant subcratonic lithospheric mantle (SCLM). Individually, mechanisms for their formation remain controversial, and together they provide no clear picture of the tectonic style prevalent during the late Hadean and Early Archean. Following earlier observation that the dome-and-keel structure of granite-greenstone terranes resembles salt diapirs, we present numerical calculations that show that in pre-Archean to Middle Archean thermal regimes, mafic to ultramafic volcanics overlying a felsic basement will overturn diapirically in as few as 10 Ma, displacing as much as 60% of the volcanics to the lower crust. This suggests that diapirism may have dominated Hadean and Early Archean crustal tectonics. Furthermore, repeated cycles of bimodal volcanism and crustal recycling by diapirism provide a mechanism for making TTGs, leaving a restite that contributes to the SCLM from above. This diapiric tectonism later declined as the Earth cooled and plate tectonics became the dominant paradigm.



From Geology, June 2009

Figure 3. Typical overturn evolution. For intermediate thermal parameters (see Fig. 2) and a hydrously altered volcanic sequence, overturn occurs in just more than 10 Ma. In B, the keel has reached 20 km depth, which is our reference depth for overturn time (τ_{20}) and keel-to-dome ratio (K:D) (see text). The line at 8 km depth (shown in A, B) has no physical significance; it outlines advection of material into the keel.

EXHIBIT D

Arguments from the co-editors of the journal ***Paleoceanography***

The decision was made by the AGU Publications committee without consultation of Eelco Rohling or Jerry Dickens, the two Editors of Paleoceanography -- the AGU journal most impacted by the decision. Indeed, they only found out about the change when authors started asking them (and complaining) after copy- editors insisted on changes. One editor seriously considered resigning over this issue.

First, and foremost, the decision confuses the scientific meaning, especially in papers that go back and forth between absolute and relative age (i.e., numerous papers in Paleoceanography) or in some radiocarbon work. Such differentiation is important in geology because the errors on absolute age and relative age differ. For example, something may have occurred around 65 Ma (+/- 0.5 myr) but the duration may <1 yr.

There is widespread scientific use of relative and absolute measurement in temperature (K and °C). The proposed change is somewhat analogous to removing °C from the literature;

There are problems raised in geology if year is used as a single unit. These pertain to the facts that the Julian, sidereal and seasonal year vary in the time domain. This becomes more problematic as we increasingly date things using astronomical calibrations;
a, the indefinite article, is a very common word in English language.

3. BASE OF THE JURASSIC

Revised GSSP Statement:

The Global Stratotype Section and Point (GSSP) defining the base of the Hettangian Stage, Lower Jurassic Series, and Jurassic System is proposed in the Kuhjoch section, Karwendel Mountains, Northern Calcareous Alps, Austria (47°29'02"N/11°31'50"E).

The proposed GSSP is situated 5,80 m above the base of the Tiefengraben Member of the Kendelbach Formation and corresponds to the FO of the ammonite *Psiloceras spelae* GUEX subsp. *tirolicum* Hillebrandt & Krystyn.

Other markers include the FO 3.2 m lower of the widely distributed continental palynomorph *Cerebropollenites thiergartii* which is the best palynomorph proxy for the determination of the T-J boundary and allows a correlation with nonmarine sediments, the FO 60 cm lower of the aragonitic foraminifer *Praegubkinella turgescens* and of the ostracod *Cytherelloidea buisensis* and the disappearance of the ostracod *Eucytherura sagitta* immediately above the point.

The delta13Corg record shows an initial negative excursion near the boundary between the Koessen and Kendlbach formations, a shift to more positive delta13Corg in the Schattwald beds and another negative excursion at the transition of the Schattwald beds to the proximate Tiefengraben Mb. The proposed stratotype point lies within a zone of smaller negative and positive delta13Corg peaks which is superimposed on a longer lasting main negative shift.

This statement was approved by a majority of ICS voting members and is awaiting ratification by the IUGS Executive Committee.

4. ON THE RANK, EXTENT, DEFINITION, AND/OR REDEFINITION OF THE QUATERNARY, PLEISTOCENE, NEOGENE, AND PLIOCENE

This vote involved two rounds:

In the first-round ballot, three possible outcomes were voted on:

1. "Status Quo" Proposal: Pleistocene Series/Epoch remains defined by Vrica GSSP. The base of the Quaternary System/Period is formally defined also by the Vrica GSSP, corresponding to the base of the Pleistocene Series/Epoch and Calabrian Stage/Age, and serving also as the Neogene-Quaternary boundary.

2. "Quaternary" Proposal: Base of Pleistocene Series/Epoch is lowered such that the Pleistocene includes the Gelasian Stage/Age and its base is defined by the Monte San Nicola GSSP, which also defines the base of the Gelasian. In addition, the base of the Quaternary System/Period, and thus the Neogene-Quaternary boundary, is formally defined by Monte San Nicola GSSP and is coincident with the bases of the Pleistocene and Gelasian. With these definitions the Gelasian Stage/Age is transferred from the Pliocene Series/Epoch to the Pleistocene.

3. "Neogene" Proposal: Pleistocene Series/Epoch remains defined by Vrica GSSP. The Pliocene Series/Epoch is split into two series/epochs named Lower/Early Pliocene and Upper/Late Pliocene, with the later composed of the Gelasian Stage/Age and with its base defined by the Monte San Nicola GSSP. The rank of the Quaternary is changed from system/period to subsystem/subperiod; its base is formally defined by the Monte San Nicola GSSP. As a result, the Quaternary is composed of the Upper/Late Pliocene, Pleistocene, and Holocene series/epochs. The Neogene System/Period extends upwards such that it includes the Miocene, Lower/Early Pliocene, Upper/Late Pliocene, Pleistocene, and Holocene series/epochs.

The second choice was approved by a strong majority of ICS voting members. It then formed the recommendation voted upon in the second-round ballot. It was approved by ICS voting members and was ratified by the IUGS Executive Committee.

There was a great detal of thoughtful commentary which is still available for reading on the ICS website.

5. IUGS Ratification

June 30, 2009

Prof. Paul R. Bown,
Secretary, International Commission on Stratigraphy (ICS)
Department of Geological Sciences
University College London
Gower Street
London WC1E 6BT
United Kingdom

RE: **Ratification of the definition of the base of Quaternary System/Period (and top of the Neogene System/Period), and redefinition of the base of the Pleistocene Series/Epoch (and top of the Pliocene Series/Epoch).**

Dear Professor Bown,

This is to confirm the receipt of your Commission's request of June 2, 2009 for ratification of its recommendation that:

1) the base of the Pleistocene Series/Epoch be lowered such that the Pleistocene includes the Gelasian Stage/Age and its base is defined by the Monte San Nicola GSSP, which also defines the base of the Gelasian;
2) the base of the Quaternary System/Period, and thus the Neogene-Quaternary boundary, be formally defined by the Monte San Nicola GSSP and thus be coincident with the bases of the Pleistocene and Gelasian, and
3) with these definitions, the Gelasian Stage/Age be transferred from the Pliocene Series/Epoch to the Pleistocene.

I am pleased to report that these recommendations were approved by a majority vote of the IUGS Executive Committee on 29 June 2009.

Sincerely yours,

A Riccardi

Prof. Alberto C. Riccardi
President
International Union of Geological Sciences

cc: Stan Finney, President, ICS
Shanchi Peng, Vice President, ICS
IUGS Executive Committee

6. ANNOUNCEMENT

Prague 2010 - ICS Workshop

The GSSP Concept

Charles University, Prague, Czech Republic
30 May – 3 June 2010

Sponsors: International Commission on Stratigraphy; International Union of Geological Sciences; Faculty of Science, Charles University; Czech Geological Society; Czech Academy of Sciences; Stratigraphic Committee of the Czech Republic;

Organizing Committee: Stan Finney (Chair – ICS), Shanchi Peng (Vice-chair – ICS), Paul Bown (Secretary – ICS), Petr Kraft (Director – Institute of Geology and Palaeontology, Charles University, Prague), Dr. Petr Storch (Czech Academy of Sciences, Prague)

Participants: Members of the full commission of ICS (ICS executive officers and chairs of all subcommissions) and the ICS webmaster are expected to attend. Vice-chairs and secretaries of all subcommissions are encouraged to attend. All other members of subcommissions and additional members of the stratigraphic community with significant contributions to make are also welcome.

Objectives: The goals of the workshop are expressed in the list of agenda items. The primary focus is on the success of the GSSP process. Discussion will include examples of successes and their broader implications, but also problems that have arisen will be discussed with suggestions for best addressing them. Preparing GSSP proposals, leading ICS subcommissions, resolving differences in usage of stratigraphic nomenclature and classifications, revising ICS statutes, setting ICS standards are additional topics that will receive considerable attention. If possible, recommendations will be made on some of these issues and formal votes may be taken on them by the ICS full commission.

Format of Workshop: No abstracts will be submitted; no publications will be produced directly from the workshop. The format will be open discussions in both full meetings of all participants and smaller groups focusing on specific agenda items. Of course, we will recruit specific presentations that lead or open discussions, and we will consider requests of participants to make specific presentations, but these will be accepted and organized solely for promotion of the agenda. Focused group discussions on agenda items should result, in most instances, in recommendations to the ICS full commission on the closing day of the workshop and possibly formal votes on them. Of course, publications based upon these recommendations may be produced after the workshop.

Agenda Items:

1. The GSSP Concept: its success, its shortcomings, problems that have arisen, difficult boundary issues remaining.
2. The exemplary GSSP proposal – essential components, definition and correlation; how best to present a GSSP proposal.
3. Leadership of ICS subcommissions: ensuring progress on GSSPs; addressing difficult boundaries; managing conflicts, rivalries, and difficult personalities. (restricted to subcommission chairs)
4. New subcommission initiatives.
5. Future of ICS and its role in IUGS.
6. Dual versus single stratigraphic classification of geologic time and time-rock units.
7. Dual usage of "Stage".
8. Integration of varied stratigraphic records and calibrated ages with the International Chronostratigraphic Chart.
9. Revisions to ICS statutes.
10. Collaboration with national stratigraphic committees.
11. The ICS website and educational products and outreach.
12. Suggestions for additional items are welcome.

Program:

30 May Welcoming Reception (evening)
31 May Opening, Review of ICS and Subcommission matters (morning); Discussion groups address agenda items (afternoon)
1 June Discussion groups address agenda items (morning);
Discussion groups report to full meeting (afternoon);
ICS Commission considers recommendations of discussion groups (evening)

2 June Field Excursion (base Devonian GSSP at Klonk and other localities);
Walking tour of Old Town, Prague (evening)

3 June Full meeting for final discussion of workshop recommendations and votes, if appropriate; directives for further deliberations (morning);
Free afternoon;
Workshop Dinner (evening)

Venue: Lecture rooms at Charles University
Lodging: University Host House, student housing, and nearby hotels