

Geological Time Conventions and Symbols

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All science involves conventions. Although subordinate to the task of figuring out how the natural world functions, such conventions are necessary for clear communication, and because they are a matter of choice rather than discovery, they ought to reflect the diverse preferences and needs of the communities for which they are intended.

A short article published recently in both *Pure and Applied Chemistry* and *Episodes* (Holden et al., 2011a, 2011b) sets out to rationalize the definition and symbols for units of time for use in nuclear chemistry and the earth and planetary sciences. Given that the authors are members of a task group established jointly by the International Union of Geological Sciences (IUGS) and the International Union of Pure and Applied Chemistry (IUPAC), and that publication was approved by both bodies, one might reasonably assume that the recommendations reflect a workable consensus. Regrettably, they don't. They will be widely ignored in North America. How could the peer review system fail so badly in this case? What needs to be done?

The present state of affairs can be traced to the decision of the task group to depart from its stated mission of "updating the recommendations on radioactive decay constants (and half-lives) for geochronological use" in order to impose a controversial agenda with respect to time concepts. This course was pursued even after it became clear in 2009 that a consensus was lacking because the hard work of developing that consensus had never been undertaken.

At stake is whether a necessary distinction exists between the concepts of geohistorical dates (points in geological time) and spans of time. The task group argues that they are one and the same; the symbols "a" (for "annus" [year]) and ka, Ma, and Ga (for 10^3 , 10^6 , and 10^9 years, respectively) will suffice for both purposes. However, the distinction has proven vital for communication among earth scientists for more than thirty years (references in Aubry et al., 2009; Christie-Blick, 2009). According to that well-established convention, the symbols ka, Ma, and Ga refer explicitly to points in time in powers of 10^3 years before present. Spans of time require a different abbreviation or symbol: m.y. or Myr in the case of millions of years, for example.

The critical issue is not whether a single set of symbols will work or whether language will become unnecessarily cumbersome to avoid confusion. It is whether the adoption of two sets of *symbols*, not *units*, is in fact "inconsistent both

internally and with respect to SI (*Le Système international d'unités*)" (Holden et al., 2011a, 2011b), because that is the justification being offered in support of a change. This assertion cannot be sustained. No one objects to the storming of the Bastille on 14 July 1789 (a date) or to the construction of Stonehenge from 2600–1600 BC (an interval specified by two dates). In the case of the latter, we say that the job took 1000 years, not 1000 BC. The distinction between geohistorical dates and spans of geological time is conceptually analogous. There is no internal inconsistency, and the International System of Units (SI) rules don't apply to dates in either case because points in time are not units, even if they are specified in years (Aubry et al., 2009). The year, moreover, is not a part of the SI. It cannot be a "derived unit of time," the designation proposed by the task group, because under SI conventions "derived units are products of powers of base units" (BIPM, 2006). The base unit for time is the second. The task group is thus intent on fixing a problem that doesn't exist and in a manner that is at odds with their stated goal of "adherence to SI rules."

Following an airing of these issues in 2009 (Aubry et al., 2009; Christie-Blick, 2009; Renne and Villa, 2009), the task group's recommendations were considered first by the International Subcommission on Stratigraphic Classification (ISSC) and then by the International Commission on Stratigraphy (ICS) of the IUGS at its Prague workshop in late May–early June 2010. The ISSC voted to reject the task group's recommendations by a margin of 16 to 2, although many voting members did not register an opinion. After extended discussion at the ICS workshop, a straw poll of those present (about 40) was split approximately 50:50 (S.C. Finney, 2011, pers. commun. [e-mail dated 20 April]). In a closed session of the ICS Bureau on the final day of the meeting, the matter was discussed again in an attempt to reach a consensus. Finney notes that "a good many of the bureau members favored the Task Group's recommendation, but wanted flexibility in usage of the abbreviations Ma and myr at the author's discretion." (Here and below, the symbol myr is inappropriate because m is the SI prefix for 10^{-3} rather than 10^6 .) Finney continues: "They were concerned that editors of journals and other publications might require that it be followed stringently."

The following motion was approved unanimously (17 votes) and confirmed without opposition in a formal e-mail ballot distributed to all members of the Bureau: "We neither accept nor reject the IUGS-IUPAC Task Group's recommendation to apply Ma, generally, as the unit of deep time. We accept the argument for Ma as a single unit for time but would recommend flexibility, allowing for the retention of Ma as specific notation for points in time (i.e., dates) and myr as a unit of time denoting duration. We agree with the spirit of this statement."

Although the situation cried out for continued dialogue to accommodate the range of opinion, in November 2010, the IUGS Executive Committee set aside the ICS's plea for flexibility and inexplicably voted "to authorize and endorse the IUGS-IUPAC

task group publication and recommendation” (R. Calnan, 2011, pers. commun. [e-mail dated 10 May]). No response was received to repeated requests for clarification.

In parallel with these discussions, the task group’s recommendations were considered also by the IUPAC. Consistent with standard protocol, in early 2009, the Interdivisional Committee on Terminology, Nomenclature and Symbols (ICTNS) sought 14 reviews and posted the manuscript for public comment on the IUPAC website (D.St.C. Black, 2011, pers. commun. [letter dated 18 May]). On 5 July 2009, a revised manuscript was received by the ICTNS and sent back to the six reviewers who had expressed interest in seeing a revision. As an outspoken critic, I also received a copy. I responded on 6 July with a lengthy review within four hours of receipt. That the task group and ICTNS chose not to acknowledge any of my substantive criticisms is hard to square with David Black’s assertion in his letter that “all the points raised by all the reviewers were addressed satisfactorily” in the second revision received in January 2011.

On the face of it, the evaluation was thorough; however, those participating on behalf of the IUPAC would not necessarily have been aware of (or cared about) concerns being raised by earth scientists. The IUGS Executive Committee proved unresponsive to the mixed signals received from its own advisory structure. The net result is a proposed convention that may appear to the casual observer to represent the consensus of a broad community of earth scientists and chemists but is nothing of the sort.

Ironically, the outcome is also unnecessary. An editorial in the 27 April 2011 issue of *New Scientist* closes with the following observation: “But it seems perverse to risk sowing confusion by choosing a symbol that is already widely used to denote a slightly different concept. By adopting another symbol, both systems could coexist in harmony.” The task group and all of the organizations involved were presented with such a compromise (Aubry et al., 2009; Christie-Blick, 2009). That was to reserve the symbols a, ka, Ma, and Ga for geohistorical dates 10^0 , 10^3 , 10^6 , and 10^9 years before present, and to express geohistorical time in years duration as yr, kyr, Myr, and Gyr (again adopting SI prefixes). The latter could then be used in the manner that the task group recommends, with no conflict, and with the outcome eventually to be determined by usage rather than by fiat.

The following steps are recommended: (1) Both the IUGS and the IUPAC should place an immediate moratorium on the proposed convention. (2) Professional societies and journals

should maintain whatever conventions they currently use, as they see fit. (3) A new task group should be established, with broad disciplinary representation and with the explicit mission of seeking a true consensus on these and related matters.

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