by K.A. Plumb

New Precambrian time scale: Reply

Dr. H.J. Hofmann's comments on my previous article (Plumb, 1991) strike at the core of the problem of a Precambrian time scale: firstly, whether a formal time scale is required at all and, secondly, what principles and operational criteria such a time scale should embrace. Unfortunately, Dr. Hofmann appears to have overlooked the detailed discussions of Plumb and James (1986). Plumb (1991) is necessarily only a brief announcement intended to formalize the decision by the Subcommission on Precambrian Stratigraphy (SPS) of the International Union of Geological Sciences (IUGS) and to enable its immediate application to international literature. A more comprehensive publication that is in preparation will detail the principles and development of the new time scale and its nomenclature.

During the infancy of modern geology, correlation with a formal chronostratigraphic (Phanerozoic) time scale was the only means available to determine or describe the age of a rock. Now, direct chronometric or isotopic age is the simplest way to describe the age of an individual rock, particularly in the Precambrian. And clearly, chronometric ages must be used in the statistical treatment of rates of geologic processes, irrespective of any subdivision that may exist. The direct use of isotopic ages remains available throughout the time scale (Precambrian and Phanerozoic) and, indeed, is encouraged within the new IUGS scheme (Plumb, 1991).

It follows that a formal time scale or subdivision is not absolutely necessary in order to depict rocks on large-scale geological maps. The fundamental map unit in these cases is generally lithostratigraphic, usually individual formations or their equivalents (for example, tectonic, structural, metallogenic, sequence stratigraphic, and paleogeographic units). The ages of these units could be considered as simply ancillary data in the map legend and could be presented as direct isotopic ages, if the data are available.

The real need for a formal subdivision lies with the need for ease and effectiveness in scientific communication and the need for the grouping of rock units on small-scale interregional maps, and herein lies the desirability for the time scale to be significant in terms of the geologic record. In a discipline in which the use of named subdivisions is traditional and deeply ingrained, the Subcommission finds a clear preference for the use of simple time terms that are more expressive than their numerical counterparts. Regional maps generally require that the fundamental lithostratigraphic units be grouped into larger units, and, particularly at continental and intercontinental scale, this grouping is commonly and traditionally made according to age. The need for ease and effectiveness of communication requires an agreed upon and consistent (that is, formal) subdivision and nomenclature.

Such subdivision will be more effective and practical if it reflects natural geologic groupings or cycles that retain their unity when depicted on maps, for example. There will be less need or temptation to force (incorrectly) rocks and events into (unnatural) equal-unit divisions, which cross natural groupings. It will be simpler to assign rock units on the basis of field relationships and correlation alone when precise isotopic ages or other means are not available immediately. Although geologic events are diachronous and any chosen boundaries or groupings are unlikely to fit all regions equally, and although some units will span boundaries and must be described as so, recent advances in precise geochronology, sequence stratigraphy, and so on, are in fact reinforcing the existence of major cycles and parallels in geologic evolution over wide areas.

Equal-unit subdivision was considered and rejected during the very earliest deliberations of the Subcommission (James, 1973), and it has been reconsidered several times since. The feedback to the Subcommission has been that equal-unit subdivision "draws little support from the geological fraternity at large; the overwhelming preference clearly is for time units that are significant in terms of the geologic record" (Plumb and James, 1986, p. 68). Indeed, the overwhelming majority of written comments to Plumb and James (1986) accepted that "the Precambrian time scale shall be divided according to the chronometric subdivision . . ., in which time boundaries have been selected so as to enclose or delimit principal cycles of sedimentation, orogeny, and magmatism, but in which boundaries are defined in years without specific reference to any bodies of rock" (Plumb, 1991, p. 139). For practical as well as scientific reasons, this has been achieved by placing boundaries selectively at times of minimal activity or gaps in the known geologic record, the antithesis of linking the definition of units directly to the rock record, as in a chronostratigraphic sense. The time scale becomes the means to calibrate the critical review of Earth's history without inhibiting the objectivity of that review.

Dr. Hofmann devotes considerable discussion to the erroneous argument that the SPS and IUGS scheme is not strictly chronometric. The nature of a time scale, chronometric or chronostratigraphic, depends solely on how the contained units are defined, that is, by direct reference to an isotopic or "absolute" age or, in the modern context, by reference to a boundary stratotype. Nowhere is there any requirement, in itself, that boundaries actually be selected in any special way. For example, boundary stratotypes could be selected legitimately at any arbitrary point or at uniform (thickness) intervals (for example, every 1,000 m) through any arbitrarily selected sequence. In practice, they are being defined from sections judged to have maximum correlation potential and to be as near as practicable to the boundaries of the classic type sections, that is, at points judged to have maximum geologic significance or application. Direct parallels exist between the selection, definition, and application of the Phanerozoic chronostratigraphic and the Precambrian chronometric time scales.

Plumb and James (1986) make a very clear distinction between the selection and definition of time units or boundaries. The formal definitions and nomenclature as accepted by SPS and IUGS meticulously avoid all references to any specific bodies of rock or geologic events, and they define boundaries strictly by chronometric or isotopic age only (Plumb, 1991). The user can use only those chronometric boundaries in applying the scheme. Any possible prejudgment of the geologic record by nomenclature, a tenuous link at best considering the care taken in definition, is nullified by the background of the Precambrian nomenclature provided to the International Commission on Stratigraphy (ICS) and IUGS and reproduced below (items 1–4). The scheme is strictly chronometric.

Nomenclature is an essential component of any subdivision, but it has proved to be an elusive component of the Subcommission's deliberations. Convenience in expression favors the use of simple, single names, which should be unique in order to avoid confusion with any other classification. Nomenclature should transcribe into other languages with as little translation as possible, and the terms that transcribe most equally into all languages are those that have classical Greek roots. The logic of linking a chronometric scheme

and a numerically based nomenclature was readily apparent to the Subcommission, but a proposed simple and easily understood Greek-based numeric scheme (Plumb and Gee, 1986, 1987) was not received favorably by the geological community at large. The Subcommission gratefully acknowledges Dr. Hofmann's welcome suggestion (personal communication, 1987) of the nomenclature that subsequently has been adopted for the eras, but the nomenclature for periods has proved more elusive.

The Subcommission does adopt the simple principles that nomenclature for time units should be simply a set of convenient labels, so as to aid unambiguous and precise scientific communication, and that no fundamental significance should be attached to any terms. Several alternative types of nomenclature were considered carefully and rejected for various reasons by the Subcommission. As in most deliberations of this nature, the Greek names derived from geologic processes, which have been recommended and approved, represented the most acceptable compromise. In explaining the background of the Precambrian nomenclature to ICS and IUGS, the Subcommission has stressed that (1) rock units shall be assigned to time units only on the basis of age, order of superposition, and (or) stratigraphic correlation; (2) the nomenclature reflects but does not define geologic history; (3) the processes implied by the names are not diagnostic of or unique to the time units to which they apply; and (4) the processes shall not be considered in assigning rocks to the time scale.

The derivation of the recommended names very purposely plays no part, nor is even mentioned, in the formal proposal for the subdivision and nomenclature of the Precambrian (Plumb, 1991). The derivations are described only in the supporting background information to ICS and IUGS and in the more detailed publication in progress. We anticipate that the derivations soon will be lost in the routine of everyday usage, just as in the precedent provided by the Phanerozoic. There the global spread of geological knowledge has blurred the original significance and derivations of the classic terminology, as is typified by the current selection and definition of many of the new boundary stratotypes from regions that are far removed from the classic type sections.

Dr. Hofmann places considerable weight on consistency of treatment in a time scale, but Dr. Hofmann's own recommendation is inconsistent. Dr. Hofmann adopts the same boundaries, nomenclature, and uneven size of his eons and eras as the scheme recommended by SPS and IUGS has and, therefore, by default, adopts the selection of boundaries by reference to the geologic record. Only for his geons (units that do not appear currently anywhere in any code of stratigraphic nomenclature) are his equal-unit principles applied. To be consistent, Dr. Hofmann's eras should be replaced with some other unit and nomenclature and should have boundaries at something like 500, 1,000, 1,500, 2,000, and 2,500 Ma, or perhaps just 1,500 and 2,500 Ma. Dr. Hofmann's geon recommendation is but a shorthand nomenclature for rounding ages and (or) grouping rock units within 100-Ma intervals; anyone is welcome to use such rounding in appropriate circumstances as an alternative to the use of precise isotopic ages already encouraged by the IUGS scheme.

The Subcommission thanks Dr. Hofmann for his several carefully considered and learned contributions to the problems of Precambrian time scales and remains grateful for his particularly elegant solution to the nomenclature of the eras, a nomenclature now so obvious in retrospect in its parallel with Phanerozoic equivalents. However, a decision and a recommendation have been made now by ICS and IUGS after exhaustive processes and considerations of all opinions available to SPS. The test now rests with the application and acceptance, or otherwise, of the IUGS scheme by the geological community at large; indications are that this will be so.

References

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