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Partitioning the Quaternary

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ABSTRACT

We review the historical purposes and procedures for stratigraphical division and naming within the Quaternary, and summarize the current requirements for formal partitioning through the International Commission on Stratigraphy (ICS). A raft of new data and evidence has impacted traditional approaches: quasi-continuous records from ocean sediments and ice cores, new numerical dating techniques, and alternative macro-models, such as those provided through Sequence Stratigraphy and Earth-System Science. The practical usefulness of division remains, but there is now greater appreciation of complex Quaternary detail and the modelling of time continua, the latter also extending into the future.

There are problems both of commission (what is done, but could be done better) and of omission (what gets left out) in partitioning the Quaternary. These include the challenge set by the use of unconformities as stage boundaries, how to deal with multiphase records in ocean and terrestrial sediments, what happened at the 'Early-Mid- (Middle) Pleistocene Transition', dealing with trends that cross phase boundaries, and the current controversial focus on how to subdivide the Holocene and formally define an 'Anthropocene'.

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1. Introduction

For science, A.C.Crombie has identified what he calls six styles of knowing. Giving alternative routes to scientific understanding, these are: the deductive, the experimental, the hypothetical-analogical, the taxonomic, the statistical, and the evolutionary (Crombie, 1994; Kwa, 2011). Geological stratigraphy relies primarily on two such styles that feature in historical studies: the taxonomic and the evolutionary. Following recognised procedures, a framework chronology of discrete units incorporating multiple elements of geological successions can be provided, and on which a worldwide and accurate understanding of Earth history may rely. Diagnostic indicators used include sediment distribution, lithology, fossil content, chemical composition, depositional environment, vertical sequence and age. Stratigraphy is therefore a synthetic subject concerned with the origin, temporal and spatial distribution of strata in sediments and other solids. For the Quaternary, this includes ice stratigraphy.

Chronostratigraphy, the application of time to rock successions, has the goal of establishing a globally applicable standard time frame. This involves time units as represented in stratigraphical sequences, rather than time as a continuum. The chronostratigraphical scale was originally a relative one that was constructed primarily through the application of biostratigraphy to defined depositional divisions. As manifested in rock sequences, such time blocks may have a composite lithological character that is recognizably distinct from adjacent ones.

Chronostratigraphical units are 'time/rock' divisions, i.e. they refer to the materials deposited during a particular timespan. By contrast, geochronological units are the corresponding intervals of geological time. Different terms are used for each. Thus rocks representing the *Quaternary System* were deposited during the time known as the *Quaternary Period*. Within the Quaternary, as for the rest of the geological column, there have long been efforts to provide sufficient, reliable and multipurpose divisions. Frameworks allow easier navigation through this part of Earth history, so producing a useful temporal template. Identified stratigraphical units can have a variety of characteristics, so allocation of newly identified material into one or another of them carries extra information and explanatory possibilities. But such a framework has to be used in such a way as to be helpful rather than misleading.

'Partitioning' is conceived here as the cognitive process of dividing continuous time and sediments into distinct units and durations. This may be attempted for the simple reference

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convenience of dividing up long timespans, but unequivocal definition is still required, and units need to be given a start and terminating date or marker. 'Periodisation' is a term similarly used for dividing the continuum of time, whilst 'epochalism' is the thought process behind such cognitive division, which may or not conform to reality. 'Period' and 'Epoch' (when capitalised) are already used formally in stratigraphy for particular hierarchical levels in temporal division, so in this paper we generally use the term 'partitioning' to avoid ambiguity. We examine here the general distinguishing process undertaken at any level in the Quaternary.

Identified time periods are common in other historical disciplines (Table 1a, b), though not without controversy. For example, Connah (2010, p.63), describing the three-age system in archaeology as 'epochalism', wrote that: "So many archaeological writers have used this model for so long that for many readers it has taken on a reality of its own. In spite of the theoretical agonizing of the last half-century, epochalism is still alive and well … Even in parts of the world where the model is still in common use, it needs to be accepted that, for example, there never was actually such a thing as 'the Bronze Age' ".

Historians also use defined, and on occasion ill-defined, time blocks. 'Antiquity', as a time period, began to be used in the Nineteenth Century for the period before the Emperor Constantine (Le Goff, 2015); 'The Middle Ages' came originally from Petrarch (1304–1374) and was used in a chronological sense by Leonardo Bruni in 1442 and Giovanni Andrea Bussi in 1469; 'The Renaissance' started being used with Jules Michelet (1798–1874) in 1840. Some terms such as the Industrial Revolution or the Enlightenment are more process than time interval, with small beginnings and uncertain boundaries. These time periods have often been Eurocentric or nationalistic and of limited geographical application. Meaningful happenings in history can also cross initially defined boundaries as well as being asynchronous across the globe. None of the approaches above have been without challenge as to their meaningfulness.

In the Earth Sciences, period recognition historically followed and then paralleled those in the humanities in developing discrete and named episodes (Rudwick, 2005, 2008; 2014). This was broadly for similar perceived human needs as in history and archaeology, though necessarily it involved different matters to do with rocks and extended geological time. Discovering Earth's deep history (or even if it had actually had a pre-human history), attempting causal explanations, and exploring life forms in a historical context were also important. With no dated documents or reigns to go by, it was imperative to establishing at least relative age, and for practical reasons (including mineral prospecting and exploitation) to set sedimentary units from different locations within their proper places in succession sequences. Thus more than academic tidiness, or even chronology, was involved.

It needs to be firmly recognised that such division is a cognitive process, a human artifact, but using selected evidence obtained as objectively as possible. The evidence used may be taken as factual and real, but partitioning decisions are different: a matter of judgment and perceived convenience. The system is a defeasible one, that is, established through the authority of experts and liable to revision if new evidence emerges. Validity, value and general applicability have to be the criteria for judging how many and at what points boundaries are declared. If boundaries are found not to be meaningful they can be abandoned or moved, rather than being disproved in the more familiar scientific sense. If there is a need, then new ones can also be added.

Rather than reiterating or reinforcing the conceptual advantages of partition, this paper focuses on some of the problems involved in a time-boxing approach to geological time as used for Quaternary research frameworks. Earth scientists should be just as critical as those in other historical fields concerning the whole process. The practice is undoubtedly very useful, but it does depend on how meaningful and acceptably defined the divisions are, how they are used, or indeed to what extent such schema function to conceal important phenomena that cannot be set within fixed units in this way. It can be that researchers are guided towards putting everything into pre-defined time boxes that they do not actually fit. Sharp changes may be overemphasized when there are only markers of convenience in continuous trajectories.

First, we summarize how ideas have developed, then the current suite of procedures and definition criteria, and then the phases that have been formally and informally identified. The main objective of the paper is to assess limitations to the partitioning processes as currently practiced and, in particular, to draw attention to what is getting concealed, misrepresented or left out. We identify, In effect, what may be either 'sins' of commission (what is done, but could be done better) or of omission (what gets left out).

2. The development of ideas

There appears to be an underlying human need to have organising mental constructs for the division of time into different 'ages': a kind of temporal taxonomy. These have been varyingly disputed over a long history (Le Goff, 2015). In the Earth Sciences, period recognition has historically been embedded in general principles of stratigraphy (Rudwick, 2005, 2008). These were succinctly summarised in the Nineteenth Century by Archibald Geikie (1835–1924), although they owe their origin to earlier exponents such as the Comte de Buffon (1707–1788), Giovanni Arduino (1714–1795), James Hutton (1726–1797), Abraham Gottlob Werner (1750–1817), and William Smith (1769–1839). Geikie defined the

Table 1
Unit names.

History and archaeology
(a). *Historical periods*: Antiquity, The Middle Ages, The Renaissance, Modern.
(b). *Archaeological periods*: Palaeolithic, Mesolithic (Epipalaeolithic), Neolithic, Bronze Age, & Iron Age developed from the 1837 three-age system of C.J.Thomsen, 1788–1865 (Gräslund, 1987). Lubbock added Palaeolithic & Neolithic in 1865.
Earth sciences
(c). *Named ICS hierarchical levels*: Period/System, Epoch/Series, Age/Stage, Chron/Chronozone.
(d). *Place names/type sites*: Pastonian, Beestonian, Cromerian, Donau, Günz/Pre-Illinoian; Elsterian/Mindelian/Anglian/Pre-Illinoian; Rissian/Illinoian/Saalian/Wolstonian; Würmian/Wiconsinan/Weichselian/Devensian; Allerød, Bølling.
(e) *Personal names:* Dansgaard-Oeschger (D-O) events; Heinrich events (H0-6) & stadials (HS1-10); Bond events (1–8).
(f). *–cene names*: Pleistocene (1839 by Lyell), Holocene, ?'Anthropocene'.
(g). *Alphanumeric code*: Marine Isotope Stages (MIS 1–104). Boundaries may be set by phase location in time series – lows, highs or crossover points.
(h). *Numerical age*: 4.2ka, 5.9ka, and 8.2ka 'events'.
(i). *Pollen Zones*: (I-IX) from the Oldest Dryas onwards, or for the Holocene in the Blytt-Sernanda sequence (Preboreal, Boreal, Atlantic, Subboreal, Subatlantic).
(j). *Early-, mid-, late-* (lower, middle & upper, for chronostratigraphical units).
(k). *Climate identifiers*: glacial, pleniglacial, interglacial, stadial, interstadial, neoglacial, hypsithermal, optimum, pluvial, warm period (or anomaly).

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