

## Viewpoint

### Examining the case for the use of the Tertiary as a formal period or informal unit

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**Abstract.** The 'Tertiary', omitted from IUGS-approved timescales since 1989, is still in common use. With the recent re-instatement of the Quaternary as a formal unit, the question arises as to whether the Tertiary too should be reinstated as a formal period, with the 'Paleogene' and 'Neogene' being downgraded to sub-periods. This paper presents arguments for and against this proposal, stemming from discussions by members of the Geological Society Stratigraphy Commission. It is intended to stimulate discussion of the topic in the wider community.

## 1. Introduction

Should the Tertiary be reinstated as a formal period, as has happened with the Quaternary, or do the Paleogene and Neogene alone adequately represent the post-Cretaceous, pre-Quaternary time interval? Opinion remains divided. This viewpoint paper presents the results of discussions held by the Geological Society Stratigraphy Commission. The view of the majority of Commission members, in favour of reinstatement of the Tertiary Period, is presented below in the contribution by Knox et al. The minority view, opposed to Commission's proposal, is presented in the following contribution by Pearson et al. These contributions are developments of those previously published by Knox et al. (2010) and Pearson and Hounslow (2010).

## **2. The case for re-instatement of the Tertiary Period**

Although used for nearly two centuries as a standard, universal stratigraphic term, the Tertiary has been absent from the International Union of Geological Sciences (IUGS) approved timescales since 1989, with the interval between the Cretaceous and the Quaternary being represented solely by the Paleogene and Neogene periods.

More recently, the Quaternary was similarly omitted from an International Commission of Stratigraphy (ICS) sponsored time chart; although this move was not sanctioned by IUGS. Strong objections to this apparent suppression were immediately raised and led to extensive discussion between those for and against its reinstatement. The matter was finally settled by the IUGS Executive Committee on 29 June 2009, with the formal ratification of the Quaternary as a period/system within the geological timescale (Gibbard et al., 2009; Finney, 2010; Gibbard & Head, 2010). The Quaternary is thus established as a formal unit.

The ratification of the Quaternary puts a new perspective on the discussion regarding the status of the Tertiary (Walsh, 2006; Head et al., 2008; Walker & Geissmann, 2009; Menning, 2010). The Tertiary has never been explicitly eliminated by IUGS, and has continued to be used alongside the Paleogene and Neogene (Salvador, 2006). One of the arguments put forward against retention of both the Tertiary and Quaternary is that they are relics of a redundant 18th Century system that originally included the Primary and Secondary. To equate the terms Tertiary and Quaternary with Primary and Secondary is quite unjustified, however, since Primary and Secondary were abandoned long ago, whereas the Tertiary continues to be used within a wide range of the geological community. Clearly, the recent IUGS ruling on the retention of the Quaternary counters any argument for eliminating the Tertiary on the basis of its 18th Century roots.

The other main argument for abandoning the Tertiary is that the term has fallen out of use. Thus, in 2005, the ICS recommended that the Tertiary be excluded as a formal division of the geological timescale “because it is nearly redundant with the entire Cenozoic Era”. This statement was refuted by Salvador (2006), who pointed out that at that time the term Tertiary was being used more often than the terms Paleogene and Neogene. As noted by Pearson et al. in Knox et al. (2012), use of the term Tertiary has subsequently decreased, but we believe that this is a reflection of increased publication on fully marine, especially deep-sea, successions as opposed to the terrestrial and marginal marine successions that are more commonly encountered onshore. The impact of successive ICS charts and associated editorial pressure has no doubt also played a part.

Continued usage of 'Tertiary' is not confined to individual articles and books. It has also been retained by some national stratigraphical commissions (e.g., the German Stratigraphic Commission), by some national geological mapping organisations, e.g., the German Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), the French Bureau de Recherches Géologiques et Minières (BRGM) and the United States Geological Survey (Walker & Geissmann, 2009). It also continues to be widely used in the hydrocarbon industry. This continued use of 'Tertiary' reflects the need for a practical time unit that refers to the post-Cretaceous – pre-Quaternary interval. This need is most pressing in activities such as onshore mapping and in the stratigraphic analysis of terrestrial and marginal-marine successions.

Another reason for continued use of the Tertiary is that its division into Paleogene and Neogene is not especially meaningful in many stratigraphic applications. When the term Neogene was originally introduced, it was applied in Europe to younger Tertiary (Miocene and Pliocene) strata that rested unconformably on Eocene strata (and thus post-dated the climax of the Alpine orogeny). The term Paleogene was introduced initially to equate with the Eocene and was subsequently expanded to include the Paleocene and Oligocene. In its original concept, therefore, the division of the Tertiary into the Paleogene and Neogene was tectonostratigraphic as well as biostratigraphic in nature. Although the tectonostratigraphic element of the definition soon became sidelined, the application of the terms Paleogene and Neogene for many decades applied only to those regions affected by Alpine tectonism. While they have subsequently acquired international recognition, it is open to question whether they represent appropriate divisions of time at the period/system level. In recent decades it has become increasingly apparent that the most fundamental and permanent change in post-Cretaceous, pre-Quaternary global climate and environments between the Cretaceous and the Quaternary took place at the Eocene–Oligocene transition, marking the change from a greenhouse to an icehouse world (Figure 1). The Paleogene/Neogene boundary does not reflect this, and this may be one reason why many stratigraphers prefer to retain the Tertiary as the fundamental unit of time (i.e. period) between the Cretaceous and the Quaternary.

It should also be emphasised that at the time the decision was made to assign formal period rank to the Paleogene and Neogene, no compromise seemed possible with the Tertiary/Quaternary scheme. This is because the Neogene extended beyond the Tertiary/Quaternary boundary. However, following the recent decision to terminate the Neogene at the base of the Quaternary, this barrier to integrating the two schemes no longer exists, and we have a unique opportunity to give due recognition to both historical schemes for subdivision of Cenozoic time.

Whatever the motivation, the continued use of the term 'Tertiary' speaks for itself. We therefore

follow Walsh (2006), Head et al. (2008) and Menning (2010) in proposing that the interval between the end of the Cretaceous and the beginning of the Quaternary is best represented by a single period/system: the Tertiary (Figure 2). The Global Stratotype Section and Point (GSSP) for the base of the Tertiary Period/System would be that already established for the Paleogene, at El Kef, Tunisia. The Tertiary would thus have the same status as the Quaternary. One significant effect of the assignment of period status to the Tertiary would be the downgrading of the terms Paleogene and Neogene. It is clearly in the interests of stability of nomenclature that these terms be maintained, and we recommend that the Paleogene and Neogene be given sub-period/sub-system status, with their meaning remaining unchanged. It may be noted that units of sub-period/sub-system level already exist in the ICS/IUGS nomenclature, i.e. the Mississippian and Pennsylvanian divisions of the Carboniferous Period/System.

Having all three terms available as formal chronostratigraphic/geochronological units is considered to provide the most pragmatic solution to this long-standing controversy. The proposed scheme provides both specialist and non-specialist geoscientists with the most versatile vocabulary for expressing post-Cretaceous, pre-Quaternary time. It thus satisfies the needs of the whole earth science community, as well as respecting historical precedent.

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### **3. The case for retaining the Palaeogene and Neogene as periods**

In response to Knox et al. in Knox et al. (2012) and as an opposing viewpoint, we note that reinstating the Tertiary on the ICS/IUGS standard timescale and removing the ‘period’ status of Paleogene and Neogene would promote inconsistency. Moreover, as a formal stratigraphic unit, the Tertiary has little intrinsically to recommend it.

As Knox et al. in Knox et al. (2012) point out, the term ‘Tertiary’ remains in widespread use in some parts of the geological community. Equally, personal experience shows that it is obsolete in others – for example, among deep-sea Cenozoic stratigraphers and palaeoclimatologists. Meanwhile Paleogene and Neogene have achieved widespread acceptance as period-level divisions, and have been recognised as such for decades. Evidence can be gleaned from publication data (Figure 3). These show that the term ‘Cretaceous/Tertiary boundary’ has been in long-term decline in contrast to ‘Cretaceous/Paleogene boundary’, which has been on the increase and is now the more common term. A similar pattern applies to ‘Tertiary’ and ‘Paleogene’ in geoscience publication titles. Presumably this is because there are many ‘good citizens’ among the geological community who have consciously

changed their usage to conform to the IUGS standard, plus a new generation who have never used 'Tertiary'. We have no objection to continued informal use of the term; the issue is whether the ICS/IUGS should revert to using it on the official timescale, having previously omitted it, and at the same time downgrade Paleogene and Neogene to sub-period status. This move would force considerable change on stratigraphers. Such a decision should only be taken if there is an overwhelming case and solid support; but the community is evidently divided following the recent controversial decision to recognise the Quaternary as a period. Aside from the politics of the situation, there are several shortcomings inherent in the concept of the Tertiary as presented by Knox et al. in Knox et al. (2012):

1. As there is no intention to abolish Paleogene and Neogene but rather to down-grade them to sub-periods, the proposal adds a level of hierarchy to the formal timescale. Sub-periods are not recognised for most of the Phanerozoic. The proposal would lock in this unnecessary complexity for future generations of geologists to learn.
2. Knox et al. in Knox et al. (2012) question whether the Paleogene/Neogene periods represent appropriate divisions of time at the period/system level. We note that their durations (42.5 and 20.4 million years respectively) are in fact reasonable in the context of the Phanerozoic as a whole, being similar to the Ordovician [44.6 m. yr] and Silurian [27.7 m. yr] periods, for example). In contrast the Tertiary and Quaternary have a very large discrepancy in their respective durations (63 vs 2.6 million years). In the scheme of Knox et al. in Knox et al. (2012), the Paleogene sub-period is over 16 times longer than the Quaternary period! This hardly seems a rational way of parcelling geological time, particularly when a fine-scale orbital chronology is now available for most of the Cenozoic.
3. We have the 'Cenozoic era' to express the biologically important interval of time from the Cretaceous/Paleogene mass extinction to the Recent. It is not evident that "we also need a single term that encompasses both the Paleogene and the Neogene" as Knox et al. in Knox et al. (2012) suggest. Because the Tertiary is essentially the Cenozoic minus the Quaternary, with the boundary set at an arbitrary level, it has almost no intrinsic coherence either in a palaeoclimatic or biological sense. It is, in effect, the stratigraphic 'wastebasket' left over from recognising the Quaternary as a period.
4. Significant biotic and climatic events mark the Paleogene–Neogene transition, including a supposed glacial episode known as 'Mi-1' and the first radiation of some important Neogene fossil groups. However, we do acknowledge that, as Knox et al. in Knox et al. (2012) point out, a more natural place for a mid-Cenozoic 'break' might be found in the complex series of events known as the Eocene–Oligocene transition. This, however, seems more of an argument for lowering the Paleogene/Neogene period boundary (which we would not, however, advocate for consistency's sake) rather than downgrading these periods to sub-periods.

In summary, stability is best served by retaining the Paleogene and Neogene as periods and the Tertiary should be left as an informal unit.

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#### 4) Conclusions

- What do you think? Write to Colin Waters [cnw@bgs.ac.uk](mailto:cnw@bgs.ac.uk), Secretary, Geological Society Stratigraphy Commission .

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#### References

- Finney, S.C., 2010. Formal definition of the Quaternary System/Period and redefinition of the Pleistocene Series/Epoch. *Episodes* 33, 148-152.
- Gibbard, P.L., Head, M.J., 2010. The newly-ratified definition of the Quaternary System/Period and redefinition of the Pleistocene Series/Epoch, and comparison of proposals advanced prior to formal ratification. *Episodes* 33, 152-158.
- Gibbard, P. Head, M.J., Walker, M.J.C. & The Subcommittee on Quaternary Stratigraphy, 2009. Formal ratification of the Quaternary System/Period and the Pleistocene Series/Epoch with a base at 2.58 Ma. *Journal of Quaternary Science* 25, 96–102.
- Head, M.J, Gibbard P.L, Salvador A., 2008. The Tertiary: a proposal for its formal definition: *Episodes* 31, 248–250.
- Knox, R.W.O'B., Gibbard, P.L., Cope J.C.W., Gale, A.S., Powell, J.H., Rawson, P.F. Smith, A.G., Waters, C.N., Zalasiewicz, J., 2010. Tertiary: survival of the fittest? *Geoscientist* 20, 10–11.
- Knox, R.W.O'B., Pearson, P., Barry, T.L., Condon, D.J., Cope J.C.W., Gale, A.S., Gibbard, P.L., Kerr, A.C., Hounslow, M.W., Powell, J.H., Rawson P.F., Smith, A.G., Waters, C.N., Zalasiewicz, J., 2012. Examining the case for the use of the Tertiary as a formal period or informal unit. *Proceedings of the Geologists' Association* 00, 00-00.
- Menning, M., 2010. Quartär bewahrt - Tertiär aufgeben? *Geowissenschaftliche Mitteilungen* 39, 16–17.
- Pearson, P., Hounslow, M.W., 2010. Retain “Paleogene” and “Neogene” as periods. *Geoscientist* 20, 11–12.
- Salvador, A., 2006. The Tertiary and the Quaternary are here to stay. *AAPG Bulletin* 90, 21–30.

U.S. Geological Survey Geologic Names Committee, 2010. Divisions of geologic time – major chronostratigraphic and geochronologic units. U.S. Geological Survey Fact Sheet 2010–3059, 2 p.

Walker, J.D., Geissman, J.W., compilers, 2009. Geologic Time Scale: Geological Society of America, doi: 10.1130/2009.CTS004R2C. GSA Today 19, 4, 61.

Walsh, S.L., 2006. Hierarchical subdivision of the Cenozoic Era: A venerable solution, and a critique of current proposals. *Earth-Science Reviews* 78, 207–237.

#### Captions for figures

Figure 1. Cenozoic climatic trends as inferred from oxygen isotope records.

Figure 2. Proposal for the Cenozoic time scale. Age names and boundary ages are from the latest version (September 2010) of the ICS International Stratigraphic Chart ([www.stratigraphy.org](http://www.stratigraphy.org)), except for the Quaternary age names, which are taken from the ICS Subcommittee on Quaternary Stratigraphy website ([www.quaternary.stratigraphy.org.uk](http://www.quaternary.stratigraphy.org.uk)).

Figure 3. Trends in usage of the Paleogene and Tertiary. Orange curve: proportion of geoscience articles with ‘Paleogene’ in the title compared with the total with either ‘Paleogene’ or ‘Tertiary’. Note this is a very conservative comparison because it does not include ‘Neogene’. Blue curve: proportion of articles with ‘Cretaceous’ plus ‘Paleogene’ plus ‘boundary’ in the title, abstract or keywords.

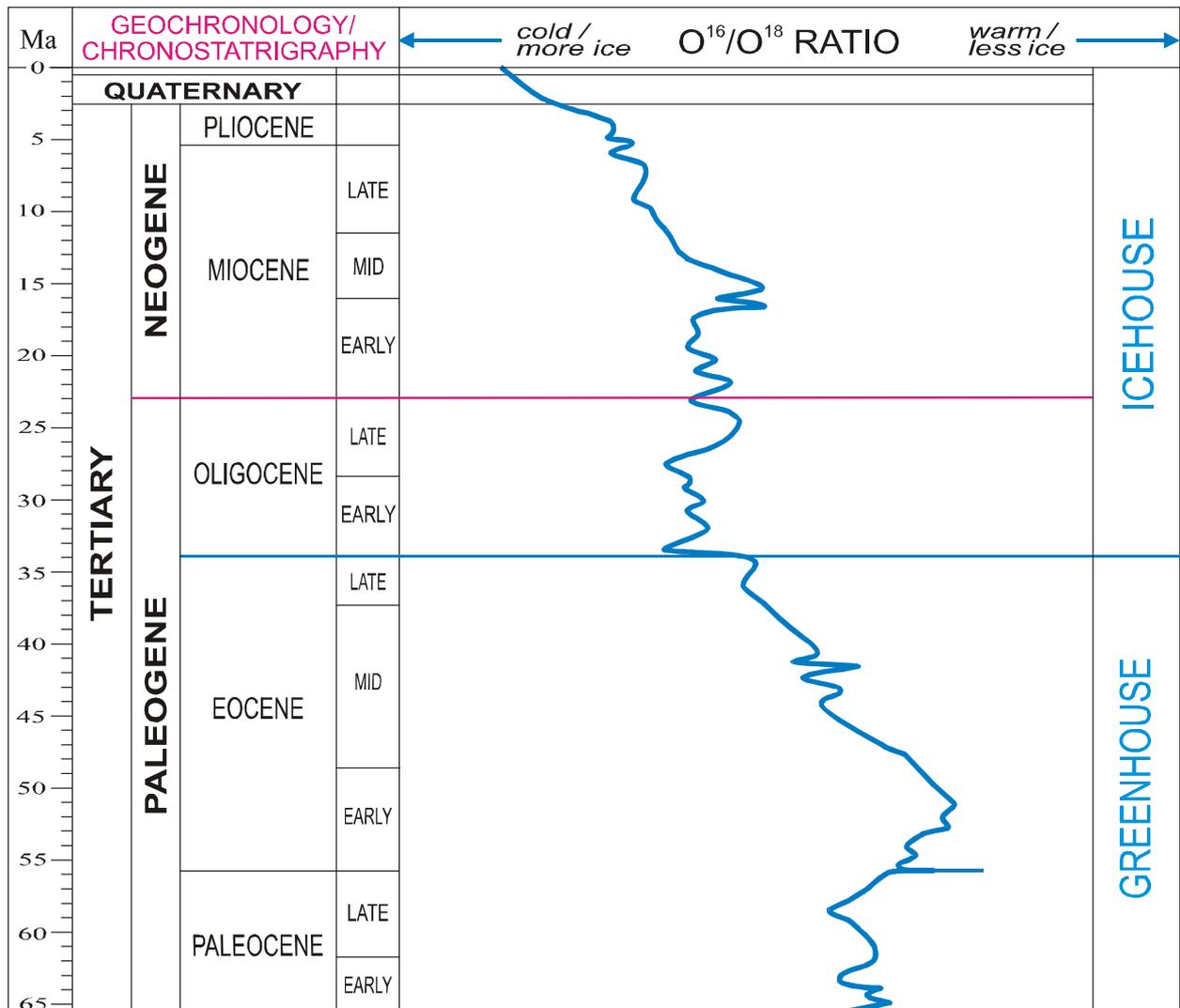


Figure 1

PRESENT PROPOSAL								
Era	Period	Sub-period	Epoch	Sub-epoch	Age	Age (Ma)	GSSPs	
Cenozoic	Quaternary		Holocene			0.012		
			Pleistocene	Mid-Late	Upper	0.126		
					"Ionian"	0.781		
				Early	Calabrian	1.806		
					Gelasian	2.588	Monte San Nicola, Sicily, Italy	
	Tertiary	Neogene	Pliocene		Piacenzian	3.600		
					Zanclean	5.332		
			Miocene		Messinian	7.246		
					Tortonian	11.608		
					Serravalian	13.82		
					Langhian	15.97		
					Burdigalian	20.43		
					Aquitanian	23.03		
				Oligocene		Chattian	28.4	
						Rupelian	33.9	
	Eocene		Priabonian		37.2			
			Bartonian	40.4				
			Lutetian	48.6				
			Ypresian	55.8				
	Tertiary	Paleogene	Paleocene		Thanetian	58.7		
					Selandian	61.1		
					Danian	65.5	EI Kef, Tunisia	

Figure 2

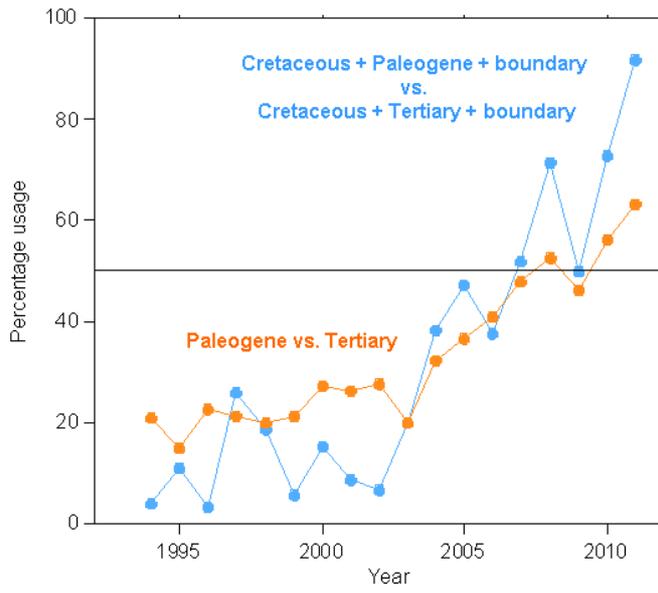


Figure 3