A REVISED CENOZOIC GEOCHRONOLOGY AND CHRONOSTRATIGRAPHY

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ABSTRACT: Since the publication of our previous time scale (Berggren and others, 1985c = BKFV85) a large amount of new magneto- and biostratigraphic data and radioisotopic ages have become available. An evaluation of some of the key magnetobiostratigraphic calibration points used in BKFV85, as suggested by high precision $^{40}Ar/^{39}Ar$ dating (e.g., Montanari and others, 1988; Swisher and Prothero, 1990; Prothero and Swisher, 1992; Prothero, 1994), has served as a catalyst for us in developing a revised Cenozoic time scale. For the Neogene Period, astrochronologic data (Shackleton and others, 1990; Hilgen, 1991) required re-evaluation of the calibration of the Pliocene and Pleistocene Epochs. The significantly older ages for the Pliocene-Pleistocene Epochs predicted by astronomical calibrations were soon corroborated by high precision $^{40}Ar/^{39}Ar$ dating (e.g., Baksi and others, 1992; McDougall and others, 1992; Tauxe and others, 1992; Walter and others, 1991; Renne and others, 1993). At the same time, a new and improved definition of the Late Cretaceous and Cenozoic polarity sequence was achieved based on a comprehensive evaluation of global sea-floor magnetic anomaly profiles (Cande and Kent, 1992). This, in turn, led to a revised Cenozoic geomagnetic polarity time scale (GPTS) based on standardization to a model of South Atlantic spreading history (Cande and Kent, 1992/1995 = CK92/95).

This paper presents a revised (integrated magnetobiochronologic) Cenozoic time scale (IMBTS) based on an assessment and integration of data from several sources. Biostratigraphic events are correlated to the recently revised global polarity time scale (CK95). The construction of the new GPTS is outlined with emphasis on methodology and newly developed polarity history nomenclature. The radioisotopic calibration points (as well as other relevant data) used to constrain the GPTS are reviewed in their (bio)stratigraphic context.

An updated magnetobiostratigraphic (re)assessment of about 150 pre-Pliocene planktonic foraminiferal datum events (including recently available high southern (austral) latitude data) and a new/modified zonal biostratigraphy provides an essentially global biostratigraphic correlation framework. This is complemented by a (re)assessment of nearly 100 calcareous nannofossil datum events. Unrecognized unconformities in the stratigraphic record (and to a lesser extent differences in taxonomic concepts), rather than latitudinal diachrony, is shown to account for discrepancies in magnetobiostratigraphic correlations in many instances, particularly in the Paleogene Period. Claims of diachrony of low amplitude (<2 my) are poorly substantiated, at least in the Paleocene and Eocene Epochs.

Finally, we (re)assess the current status of Cenozoic chronostratigraphy and present estimates of the chronology of lower (stage) and higher (system) level units. Although the numerical values of chronostratigraphic units (and their boundaries) have changed in the decade since the previous version of the Cenozoic time scale, the relative duration of these units has remained essentially the same. This is particularly true of the Paleogene Period, where the Paleocene/Eocene and Eocene/Oligocene boundaries have been shifted ~2 my younger and the Cretaceous/Paleogene boundary ~1 my younger. Changes in the Neogene time scale are relatively minor and reflect primarily improved magnetobiostratigraphic calibrations, better understanding of chronostratigraphic and magnetobiostratigraphic relationships, and the introduction of a congruent astronomical/paleomagnetic chronology for the past 6 my (and concomitant adjustments to magnetochron age estimates).

INTRODUCTION

The historical and methodologic background to the construction of the Paleogene (Berggren and others, 1985b = BKF85; Aubry and others, 1988) and Neogene (Berggren and others, 1985a = BKV85) components of an integrated Cenozoic time scale have been explained in detail. In the decade since the publication of our previous Cenozoic time scale (BKFV85), major advances in radioisotopic dating, magnetostratigraphy and (calcareous) plankton biostratigraphy, as well as the introduction of new approaches to geochronology (astrochronology; e.g., Shackleton and others, 1990; Hilgen, 1991) have forced a reevaluation and eventual updating of that study.

Cande and Kent (1992) presented a revised Cenozoic magnetochronology based on an evaluation of sea-floor magnetic anomalies. The geomagnetic polarity sequence was based primarily on data from the South Atlantic (with fine-scale data inserted from faster spreading regions of the Pacific and Indian Ocean) using a combination of finite rotation and averages of anomaly spacings from stacked profiles projected onto a synthetic sea-floor spreading flow line. The time scale was then generated by fitting a spline function to a set of nine age calibration points plus the zero-age ridge axis to the composite polarity sequence.

The present version of the global polarity time scale (GPTS) differs from that presented in Cande and Kent (1992) in the following respects: (1) the astronomical time scale values of polarity boundaries from Chron C1n to Subchron $C3n.4n_{(0)}$ (Thvera) (0–5.23 Ma) are accepted as standard which results in coherent and congruent magnetostratigraphic and astronomic chronologies back to 5.23 Ma, and (2) an age of 65.0 Ma is used for the Cretaceous/Paleocene (K/P) boundary (vs. 66.0 Ma in CK92). These changes, and the resulting modification to the GPTS, were revised in CK95.

We assess over 250 pre-Pliocene first-order (and to a lesser extent, second) correlations between calcareous plankton datum events and the GPTS, resulting in a significant improvement in biochronologic resolution and accuracy over a wide range of biogeographies and biostratigraphies compared to that proposed in 1985.

In recent years, we have witnessed a dramatic improvement in both geochronologic precision and accuracy (e.g., $^{40}Ar/^{39}Ar$ dating; astronomical chronology). The puzzling discordance between astrochronology and magnetochronology beyond ~3.5 Ma has been recently resolved and we can now look forward to the next generation of time scales, improvements to which we believe will come in the following areas: (1) extension of the astronomical time scale into the Miocene Epoch

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