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Integrating marine and terrestrial records from the late Eocene – early Oligocene of North America and Italy

Diana Sahy (1,2), Anne Fischer (3), Dennis O. Terry Jr. (4), Daniel J. Condon (1), and Klaudia Kuiper (3)

(1) NERC Isotope Geosciences Laboratory, British Geological Survey, Keyworth, Nottingham, NG12 5GG, United Kingdom (dihy@bgs.ac.uk, dcondon@bgs.ac.uk), (2) Department of Geology, University of Leicester, University Road, Leicester, LE1 7RH, United Kingdom, (3) Faculty of Earth and Life Sciences, Vrije Universiteit, 1085 De Boelelaan, Amsterdam, 1081 HV, The Netherlands (anne.fischer@falw.vu.nl, klaudia.kuiper@falw.vu.nl), (4) Earth and Environmental Science, Temple University, 326 Beury Hall, 1901 N. 13th St, Philadelphia, PA 19122 (doterry@temple.edu)

Current timescales for Late Eocene – Early Oligocene interval are based on astronomical tuning, and K/Ar and 40Ar/39Ar dating of sanidines and biotites from air fall tuffs intercalated in continuous deposits that span the E/O transition such as the terrestrial White River Group of North America and marine deposits from the Italian Apennines. In spite of recent advances including the astronomical calibration of the commonly used Fish Canyon sanidine standard, detailed global correlations are hampered by the fact that numerical age constraints and magnetostratigraphic records from marine and terrestrial sections appear to be at least in part inconsistent with each other. As part of the GTSnext project (www.gtsnext.eu) we are working on refining the Eocene-Oligocene time scale by integrating high-precision U-Pb (zircon, monazite) and 40Ar/39Ar (sanidine) geochronology of air fall tuffs, magnetostratigraphy, biostratigraphy, and astronomical tuning, in order to improve the correlation of marine and terrestrial records.

Our study targets sections that are biostratigraphically well constrained and have been the subject of extensive previous geochronologic work: the Massignano section (which contains the GSSP for the Eocene – Oligocene boundary) and the nearby Monte Cagnero section in the Marche-Umbria basin of Italy, and the Flagstaff Rim (Wyoming) and Toadstool Geologic Park (Nebraska) sections from the White River Group, which host vertebrate fossils used to define the Chadronian and Orellan North American Land Mammal Ages considered equivalent to the marine Eocene and Oligocene. Together these sections cover an interval of about 5 Myr, from the top of chron C16n.2n to the base of C12n. Four of the 'biotite-rich' layers sampled at Massignano have so far yielded preliminary U-Pb ID-TIMS ages which are in good agreement with depositional models based on astronomical tuning of the same section. Additionally, the age of 33.77 Ma obtained by linear interpolation based on data from tuffs at metre levels 12.7 and 14.7 is indistinguishable from the astronomically tuned 33.79 Ma date obtained at ODP Site 1218 for the Eocene-Oligocene boundary. Preliminary 238U-206Pb ages were obtained from 16 tuffs sampled in the two White River sections. U-Pb dates are consistently younger than previously published 40Ar/39Ar data by as much as 0.8 Myr. New 40Ar/39Ar sanidine dates calculated using an age of 28.201 for the Fish Canyon Tuff are in good agreement with U-Pb ages determined on zircons from the same samples, indicating that although the discrepancy between the U-Pb and earlier 40Ar/39Ar datasets appears to be relatively constant throughout the sections it is not caused by a systematic bias between the two radio isotopic systems, but possibly due to sample preparation, interlaboratory bias or the use of different 40Ar/39Ar data reduction techniques.

In spite of these improved numerical constraints existing magnetostratigraphic records of the investigated marine and terrestrial sections continue to show large discrepancies both in terms of the timing of reversals and the duration of individual chrons. This is particularly evident in the case of chron C13r which appears to be anomalously short in the Toadstool Park section, spanning approximately 0.4 Myr as opposed to approximately 1.2 Myr in the Massignano section, whereas chron C15r appears to span a far longer time at Flagstaff Rim ($\sim$1.3 Myr) than at Massignano ($\sim$0.3 Myr). This appears to indicate that difficulties in correlating Late Eocene – Early Oligocene records are due not only to anomalously old ages obtained from some of the North American tephras but also to errors in the magnetostratigraphic record of some of the sections used for correlation.