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Miocene to recent eolian dust record from the Southwest Pacific Ocean at 40° S latitude

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Abstract

A 14-meter long pelagic clay core recovered at Marlin Rise (40°00.531′S, 154°2.601′W; 4775 m water depth) in the Southwest Pacific Basin contains a record of eolian dust deposited since the early Miocene. Downcore analysis of detrital minerals reveals a dominantly eolian signature with relatively constant proportions of quartz, feldspar and illite and trace amounts of chlorite, kaolinite and smectite, consistent with a continental (loess-like) source region. Fish tooth Sr isotope stratigraphy reveals the base of the core to be 17.5 Ma, with low sedimentation rates (<0.5 mm/kyr LSR) indicated for the interval 17.5 to 10 Ma; several hiatuses in deposition appear to be present upcore, but are beyond the age resolution of the fish teeth stratigraphy. These intervals are revealed as apparent discontinuities in the Sr isotope record, accompanied by pulses of anomalously rapid sedimentation at ~10 Ma, 6.7 Ma and 4.1 Ma. Bulk mass accumulation rates (MAR) are calculated at ~10 mg/cm^2/kyr over the last 4 Myr, consistent with previously estimated Quaternary eolian flux rates to this part of the Pacific. Nd, Pb and Sr radiogenic isotopic compositions of the detrital mineral extract (<38 µm) show no trends with age, while ^{40}Ar/^{39}Ar ages show an upcore younging trend (~180 Ma to ~150 Ma), in concert with a slight coarsening of eolian grain-size distributions. These ages likely reflect mixing of Mesozoic illite-dominated clay from at least two continental source areas: southeastern Australia (Murray–Darling Basin/Lake Eyre Basin) and New Zealand (South Island). The data indicate remarkable constancy of continental eolian sources exposed to weathering and dispersal at this latitude during the Neogene.

Keywords: Eolian dust sources; South Pacific; Sr–Nd–Pb–Ar isotopes; Marlin Rise

1. Introduction

Long-term records of Cenozoic eolian dust accumulation for the remote South Pacific Ocean are essentially lacking (Rea, 1994). At present, most of the South Pacific is thought to be characterized by minimal dust input (<10 mg/cm^2/kyr; Rea, 1994), except for areas directly downwind of eastern Australia and New Zealand. Quaternary ice-core dust records from Antarctica have more recently been used to suggest wider dispersal and circulation of dust from these sources to remote parts of the Southern Hemisphere (Delmonte et al., 2004; Grousset and Biscaye, 2005; Revel-Rolland et al., 2006). Radiogenic isotope data have fingerprinted Patagonia as an important source of dust in Antarctic ice cores delivered during South American glacial episodes (Grousset et al., 1992; Basile et al., 1997), while recent work by Revel-Rolland et al. (2006) has identified Australia as a primary dust source during interglacial times. While very little dust from South America travels west with the tradewinds into the South Pacific, Rea (1994) noted that southeastern Australia contributes a moderate amount of dust to the western South Pacific in quantities of up to 200 mg/cm^2/kyr. The extent of the Australian influence has not been tracked beyond this region in detail (Leinen et al., 1986). Hesse (1994) suggested a 2 to 9-fold increase in dust flux to the Tasman Sea from southeastern Australian sources during glacial maximum events, increasing near 40°S latitude. Kohfeld and Harrison (2001) also modeled large increases in

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South Pacific dust accumulation rates during glacial intervals within the 35–40°S latitude band. Tanaka and Chiba (2006) concluded that Australia currently dominates Southern Hemisphere dust production, although Mahowald et al. (1999) have cautioned that modern dust production rates are commonly overestimated. Few data currently exist for estimating contributions of the New Zealand (South Island) loess fields to the eolian flux in the South Pacific region (Rea, 1994).

A detailed study of Cenozoic dust deposition was carried out at DSDP Site 596 (24°S, 170°W; Fig. 1) in the northern South Pacific, where Zhou and Kyte (1992) identified a rapid increase in the eolian flux starting at ~3 Ma, concurrent with the late Pliocene increases in eolian flux observed for many North Pacific cores (Janecek and Rea, 1983; Rea, 1994). Stein and Robert (1985) examined sediment cores on the Lord Howe Rise (Tasman Sea) along a transect between 26–36°S, 160°E, finding some evidence for increasing dust flux over the last 4 Myr. They also observed an upcore change in clay mineralogy during the Miocene, from illite–smectite dominated clays to kaolinite–illite dominated clays, a transition linked to aridification of Australia beginning ~15 Myr ago (Stein and Robert, 1985). Rea and Bloomstine (1986) and Bloomstein and Rea (1986) examined the pelagic clay record from ODP Leg 92 in the South Pacific along the west flank of the East Pacific Rise (19°S, 135°W–125°W), finding variation in eolian grain size that suggested a more energetic atmospheric circulation starting at ~10 Ma; however, they identified no significant change in late Cenozoic eolian flux rates. Others have concluded that there was an increase in late Cenozoic dust flux rates in the South Pacific, though not of the same magnitude as that observed by Zhou and Kyte (1992) for the northern South Pacific, or for the North Pacific (e.g., Kyte et al., 1993). In general, an increase in Southern Hemisphere dust production starting in the Miocene has been thought to be consistent with aridification of Australia as this landmass moved northward into the desert latitudes and the climate cooled (concurrent with the buildup of Antarctic ice sheets); increased grain size is also consistent with stronger winds associated with southern hemisphere cooling (Rea, 1994).

The core reported on here is from a remote region of the South Pacific that promises to help fill some key gaps in our understanding of late Cenozoic eolian flux and Southern Hemisphere dust production. In February 2005, the R/V Melville (drill site survey cruise TUIM-03) recovered a large-diameter jumbo piston core (MV0502-01JC) containing 14 m of pelagic red clay from Marlin Rise in the South Central Pacific, 2400 km east of New Zealand (Site SP-15; Rea et al., 2006). Core MV0502-01JC was recovered at 40°00.531′S, 154°2.601′ W in 4775 m water depth (Fig. 1). This site is situated near the southwestern edge of the South Pacific bare zone, an area of the SW Pacific Basin that records little or no Cenozoic sediment accumulation (Rea et al., 2006; Stancin et al., in press). Site SP-15 exhibits a classic pelagic sediment drape atop 79 Ma basement (Fig. 2), with sediment thicknesses estimated at ~90 m (SPLAT site survey report, unpublished; M. Lyle, personal communication). A prominent acoustic reflector at ~20 mbsf (meters below sea floor — Fig. 2) was not penetrated by the 14 m piston core. This paper reports on the age, provenance and likely origin of the eolian component in the pelagic clay from this site, which was studied using chemical extraction procedures documented by Rea and Janecek (1981), Hovan (1995) and Stancin et al. (2006). The core material (light brown to dark brown zeolitic clay plus red-brown semi-opaque oxides) is barren of microfossils, except for ubiquitous fish teeth. It was therefore necessary to employ the technique of strontium isotope fish teeth dating in order to construct an accurate stratigraphic record (Gleason et al., 2002, 2004a,b). Mineralogic and radiogenic isotopic analysis was performed on the extracted terrigenous component of the core to help constrain its provenance, resulting in a long-term eolian source record spanning early Miocene to recent time. This record is apparently unique thus far for the Southwestern Pacific Basin, and its implications are discussed below.

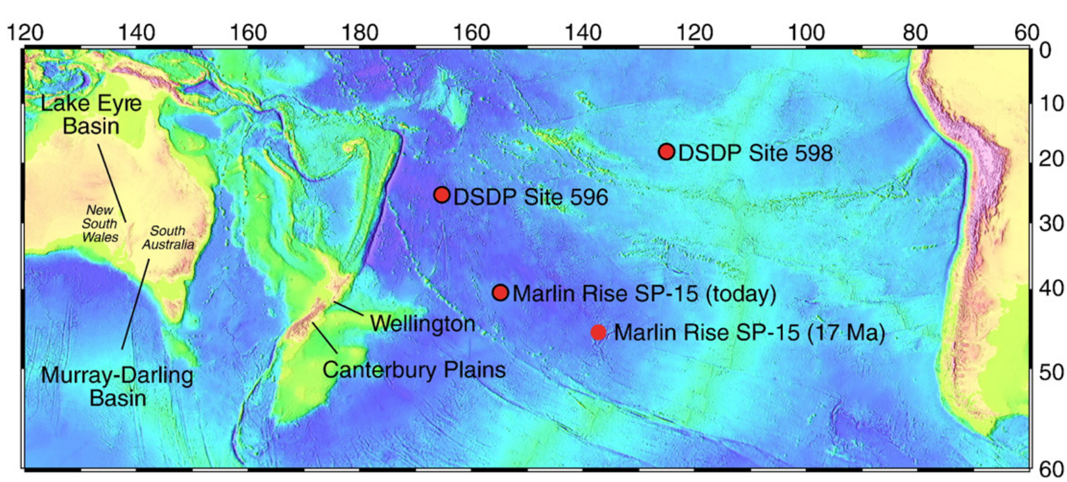

Fig. 1. Location of Marlin Rise, Site SP-15 and piston core MV0502-01JC (40°00.531′S, 154°2.601′W; 4775 m water depth) in the SW Pacific Basin. DSDP Sites 596 (Zhou and Kyte, 1992) and 598 are discussed in the text, along with potential dust sources in SE Australia and New Zealand. The 17.5 Ma backtrack paleoposition for site SP-15 was calculated using a spreadsheet of pole rotations from Gripp and Gordon (1990). Bathymetric base map modified from Rea et al. (2006).