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Comparison of radiolarian and sedimentologic paleoproductivity proxies in the latest Miocene–Recent Benguela Upwelling System

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Abstract

Estimating past ocean productivity from ocean sediments often gives different results depending on the measurement used. We have examined a suite of paleoproductivity proxies in latest Miocene–Recent sediments from DSDP Site 532 and ODP Site 1084, two deep-sea sections underlying the Benguela Upwelling System off the Atlantic coast of southern Africa. The productivity history of this system has been previously established via organic carbon concentration, diatom floras and alkenone based estimates of surface water temperature, and shows a change from low productivity in the early Pliocene to sustain high productivity in the late Pliocene–Recent. Each of our samples was split and simultaneously analysed for several proxies of ocean productivity, including organic carbon (TOC%), carbonate, abundance of opaline radiolarians, accumulation rate of benthic foraminifera (BFAR); the radiolarian faunal composition indices Upwelling Radiolarian Index (URI) and the Water Depth Ecology index (WADE); other proxies for opal and carbonate dissolution, plus stable isotopes of benthic foraminifera. Comparisons between proxies in the same measured samples, between sites in downcore plots and to the published productivity record for this region suggest that TOC and radiolarian faunal composition, particularly the WADE index, are good indicators of past productivity, albeit with different sensitivities (log–linear correlation WADE–TOC% $r=0.78$, $n=65$, $p<0.01$). In contrast, carbonate, and carbonate-based proxies such as BFAR primarily reflect changes in dissolution. Radiolarian faunal composition indices do not appear to be affected by bulk opal accumulation or changes in opal preservation. WADE analysis of radiolarian faunas and TOC% measurements appear to be useful proxies for productivity in late Neogene sediments, particularly for sections where opal or carbonate dissolution is significant.

Keywords: Micropaleontology; Nutrient cycling; Paleoproductivity; South Atlantic; Neogene; Organic carbon

1. Introduction

Oceanic productivity plays an important role in the global carbon cycle, particularly by export of biologically fixed carbon to deep waters and sequestration of carbon in ocean sediments. Understanding this complex process is best achieved using a variety of approaches, including study of past changes in ocean productivity as recorded by paleoproductivity proxies in marine sediments. Many different paleoproductivity proxies exist, but, for various reasons, no single proxy gives consistently reliable results. This issue has led to the use of multiple proxies, in the hope that a reasonably consistent

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consensus picture of past productivity change will emerge (Wefer et al., 1999). Recent research on the paleoproductivity history of the Benguela Upwelling System exemplifies this multi-proxy approach.

The Benguela Upwelling System is a region of nearshore upwelling cells and offshore transport of high-productivity water filaments in the Benguela eastern boundary current region of the South Atlantic off the southwestern coast of Africa (Hay and Brock, 1992; Fig. 1). Dominantly offshore wind stress near the coast draws nutrient-rich waters from ca. 100–200 water depth to the surface in coastal upwelling cells. High algal production in this water is exported offshore in long, narrow filaments, is carried north by the Benguela Current and related current

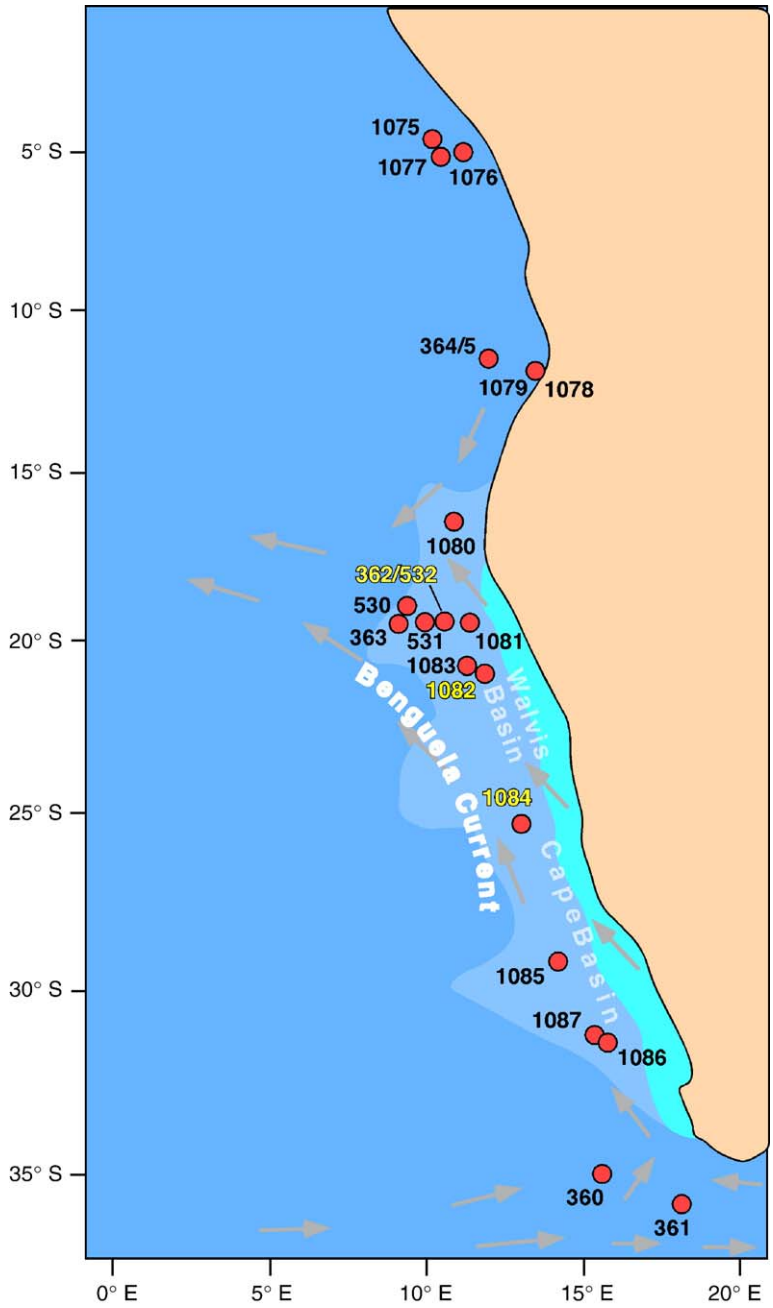

Fig. 1. Map showing major currents, extent of upwelling near coast and extent of upwelling influenced water further offshore from transport of filaments, and DSDP–ODP Site locations. Sites in bold/yellow have substantial downcore radiolarian data (prior work plus this study). Redrawn from Wefer et al. (1998). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)