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Clay mineral assemblages, siliciclastic input and paleoproductivity at ODP Site 1085 off Southwest Africa: A late Miocene–early Pliocene history of Orange river discharges and Benguela current activity, and their relation to global sea level change

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Abstract

A late Miocene to early Pliocene sequence drilled on the continental slope of southwest Africa off the Orange river mouth (ODP Site 1085) has been investigated. Clay mineral assemblages, coarse siliciclastics and benthic foraminifer accumulation rates (BFAR) unravel a step by step evolution of marine and continental environments closely related to sea level variations, ocean circulation and global climate: (1) smectite is a typical tracer of the Orange river load, whereas illite is mostly transported by the Benguela current (like chlorite) and winds, and kaolinite is derived from low latitudes by the poleward undercurrent and the North Atlantic Deep Water (NADW); (2) increased erosion and influence of the Orange river after 9.6 Ma is linked to a sea level drop at a time of Antarctic ice-growth. This has been followed by an increased seasonality of precipitation and high productivity, but low oxygen content and associated dissolution of carbonates; (3) increased productivity and dissolution of carbonates, and coeval increase of continental aridity after 8.9 Ma express a further development of the Benguela current and upwelling; (4) better preservation of carbonates and increased contribution of terrigenous material from northern sources at 6.9 Ma are related to increased circulation of NADW after an early stage of northern hemisphere glaciation; (5) increased erosion and contribution from the Orange river and westward shift of the area of higher productivity from 5.9–5.8 Ma to 5.3–5.2 Ma are related to a significant fall of sea level, and encompass the time of the entire Mediterranean salinity crisis; (6) short-term variations of the smectite/illite ratio (S/I) and BFAR suggest a major control of productivity by wind and current activities (and related upwelling), but may express brief variations of sea level in specific intervals before 8.9 Ma and during the late Messinian especially.

Keywords: clay minerals; siliciclastics; productivity; Benguela current; South Africa; late Miocene; sea level; climate

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1. Introduction

The Benguela current and Antarctic Intermediate Water circulation participate in the meridional thermal exchanges that intensify at times of higher equator to pole temperature gradients. These circulations probably intensified in the earliest Oligocene, when antarctic nannofossils and clay minerals are carried as far north as DSDP Site 526 on the Walvis Ridge (Manivit, 1984; Robert and Chamley, 1992). The upwelling started and probably initiated aridity of the Namib area later in the early late Miocene (Siesser, 1980; Diester-Haass et al., 1990), when an ice-sheet spread over West Antarctica. Late Miocene changes of southwest African and southeast Atlantic environments, and the development of West Antarctic ice are probably more than a coincidence. However, the late Miocene to early Pliocene evolution of Antarctic ice and climate remains controversial. The Antarctic ice-sheet may have either fluctuated of more or less 50% of its present size, or remained relatively stable after its growth (Wise et al., 1985; Crowley and North, 1991). Intervals of ice growth should have been associated with strong Antarctic circulation, with repercussions on the Benguela system and climate of the adjacent continent. Ice expansion also generates variations of sea level, which have been mostly investigated in continental shelf terrigenous sequences and carbonate platforms (Haq et al., 1987; Betzler et al., 2000). Sea level variations are not commonly evidenced from deep-sea sequences. However, intervals of sea level fall have been inferred from the frequency of turbiditic events in the deep Labrador Basin, and their correlation to intervals of high $\delta^{18}O$ (Zhang and Scott, 1996). Because of their consequences on the physiography of coastal areas and erosional processes in continental drainage basins and shelves, major sea level variations should be associated to changes in the clastic input from rivers and composition of clay mineral assemblages (Chamley, 1989; Diester-Haass et al., 2004).

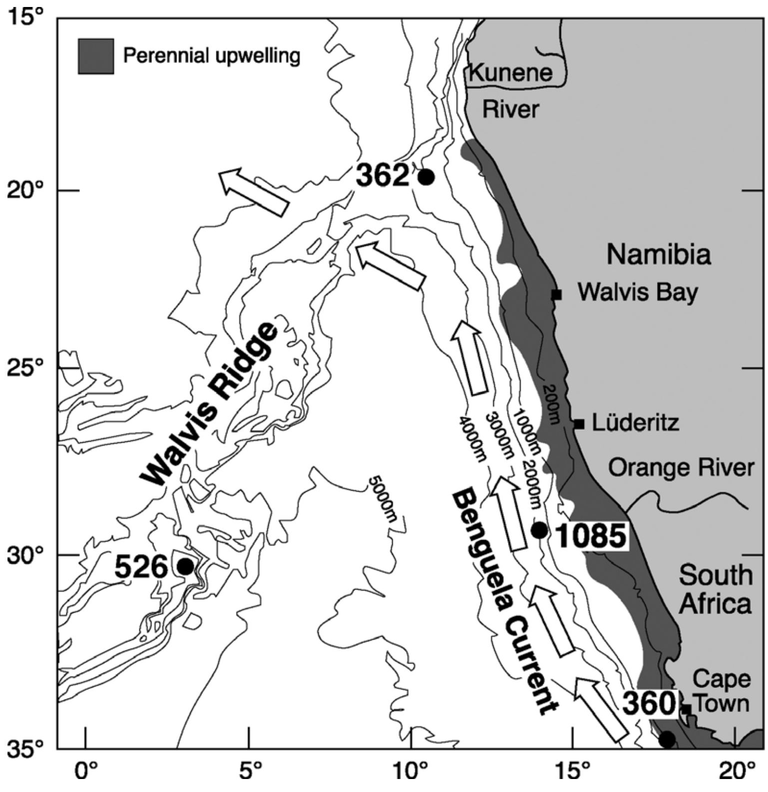

Fig. 1. Location map. ODP Site 1088 (41°S; 13°E) is located about 700 km southwest of DSDP Site 360.