Available online at www.sciencedirect.com
ScienceDirect
Sedimentary Geology 202 (2007) 499 – 508
Sedimentary Geology
www.elsevier.com/locate/sedgeo

Variability in terrigenous sedimentation processes off northwest Africa and its relation to climate changes: Inferences from grain-size distributions of a Holocene marine sediment record

Christine Holz *, Jan-Berend W. Stuut, Rüdiger Henrich, Helge Meggers

Department of Geosciences, University of Bremen, P.O. Box 330 440, 28334 Bremen, Germany

Abstract

Variations in deposition of terrigenous fine sediments and their grain-size distributions from a high-resolution marine sediment record offshore northwest Africa (30°51.0′N; 10°16.1′W) document climate changes on the African continent during the Holocene. End-member grain-size distributions of the terrigenous silt fraction, which are related to fluvial and aeolian dust transport, indicate millennial-scale variability in the dominant transport processes at the investigation site off northwest Africa as well as recurring periods of dry conditions in northwest Africa during the Holocene. The terrigenous record from the subtropical North Atlantic reflects generally humid conditions before the Younger Dryas, during the early to mid-Holocene, as well as after 1.3 kyr BP. By contrast, continental runoff was reduced and arid conditions were prevalent at the beginning of the Younger Dryas and during the mid- and late Holocene. A comparison with high- and low-latitude Holocene climate records reveals a strong link between northwest African climate and Northern Hemisphere atmospheric circulation throughout the Holocene. Due to its proximal position, close to an ephemeral river system draining the Atlas Mountains as well as the adjacent Saharan desert, this detailed marine sediment record, which has a temporal resolution between 15 and 120 years, is ideally suited to enhance our understanding of ocean–continent–atmosphere interactions in African climates and the hydrological cycle of northern Africa after the last deglaciation.

Keywords: Aeolian dust; Climate; End-member model; Grain size; Holocene; Northwest Africa

1. Introduction

Hemipelagic sediments deposited on continental margins are important archives monitoring land–ocean interactions and their variability related to climate oscillations on various temporal and spatial scales. The terrigenous fraction of marine sediment records reflects the input of material produced on and discharged from continents, which is directly related to climate conditions in the hinterland.

For a long time, the Holocene climatic period was considered as a rather stable period in Earth history. However, many investigations provide evidence that the Holocene climate of the North Atlantic region exhibits variability on (sub-)millennial timescales (e.g. Bond et al., 1997). In addition, marine, terrestrial and limnological studies show evidence of large-amplitude changes in the hydrological cycle, particularly in the African tropics and subtropics but also in the Mediterranean realm during the last deglaciation (e.g. Roberts et al., 1993; Gasse, 2000;

* Corresponding author. Fax: +49 421 218 7431.
E-mail address: cholz@uni-bremen.de (C. Holz).

0037-0738/$ - see front matter
doi:10.1016/j.sedgeo.2007.03.015

deMenocal et al., 2000a; Stein, 2001; Swezey, 2001; Arz et al., 2003). Palaeohydrological changes in Africa, over the period for which radiocarbon dating is possible, appear to have been a complex alternation of wet and dry episodes with abrupt transitions (e.g. Gasse, 2000; deMenocal et al., 2000a). From about 10,000 to 4000 years ago, Neolithic civilizations flourished in a relatively humid and green Sahara, and land-locked lakes in northern East Africa extended tens or even hundreds of metres above their present level (Gasse, 2000).

Today, the Sahara Desert, one of the world's most important source regions for mineral dust formation (e.g. Harrison et al., 2001), represents a major source of terrigenous sediments. However, next to aeolian dust, there is another important source of terrigenous sediments deposited along the northwest African continental margin. A number of permanent and ephemeral rivers transport sediments derived from the hinterland of the Atlas Mountain range to the continental shelf off Morocco (see Fig. 1). This has recently been confirmed by studies which point to a fluvial contribution off northwest Africa (e.g. Holz et al., 2004; Kuhlmann et al., 2004). The total discharge of suspended sediment by northwest African rivers is estimated at 110 million tons per year (Hillier, 1995).

The modern climate of northwest Africa is dominated by two climate systems, the Mediterranean and the northwest African monsoonal climate systems, which are separated by the Saharan desert belt (Nicholson, 2000). South of ~20–24°N, summer monsoonal rains play a major role in subtropical African climate whereas north of this, precipitation is dominated by North Atlantic and Mediterranean winter rains (Knippertz et al., 2003). Therefore, gravity core GeoB 6007-2 (30°51.0′N, 10°16.1′W), which was retrieved during RV METEOR cruise M 45/5 (Neuer et al., 2000) at a water depth of 900 m (Fig. 1), was anticipated to have recorded variations in these winter rains and to be influenced by the North Atlantic climate (Kuhlmann et al., 2004). The sediment core was recovered from a region where hydroacoustic profiles indicate layered sediments and an undisturbed sediment cover (Neuer et al., 2000). Furthermore, the homogenous fine-grained sediment record does not show indications of gravity flow. With an average sedimentation rate of ~85 cm/kyr for the past 13.5 kyr, the marine sediment record reflects variability

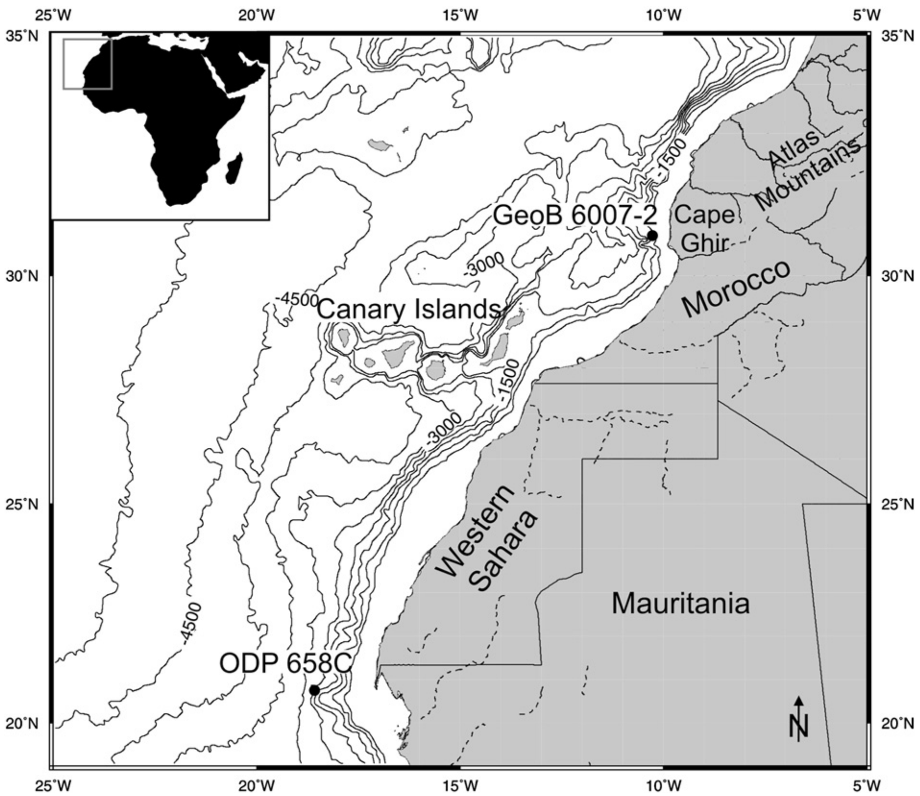

Fig. 1. Contour map (500 m) of the northwest African continental margin showing locations of site GeoB 6007-2 off Cape Ghir, Morocco, and of Ocean Drilling Program (ODP) Site 658C off Cape Blanc, Mauritania. All permanent and intermittent rivers of northwest Africa are indicated. The figure was created using Generic Mapping Tools (Wessel and Smith, 1991).