Available online at www.sciencedirect.com

ScienceDirect

Journal of African Earth Sciences 49 (2007) 79–89

Journal of African Earth Sciences

www.elsevier.com/locate/jafrearsci

Late Holocene environmental change in the coastal southern Somalia inferred from *Achatina* and rhizoliths

R. Matteucci [a,*], G. Belluomini [b], L. Manfra [a]

[a] *Dipartimento di Scienze della Terra, Università degli Studi di Roma La Sapienza, P.le Aldo Moro, 5, 00185 Roma, Italy*
[b] *Istituto per le Tecnologie Applicate ai Beni Culturali, CNR, Area della Ricerca di Roma, Via Salaria, Km 29.300, 00016 Roma, Italy*

Received 4 May 2006; received in revised form 24 April 2007; accepted 3 July 2007
Available online 10 July 2007

Abstract

Surfaces of poorly cemented carbonate dunes of the coast of southern Somalia contain as exhumed bodies treelet rhizoliths and subfossil shells of the giant land snail *Achatina*. Present-day coastal dunes in southern Somalia are poorly vegetated and do not support living Achatinas. Thus, the presence of these subfossils provides evidence for a more humid period in the past: the subfossil giant land snails and the rhizoliths indicate a palaeoenvironment which was probably similar to the modern environment of the coastal belt of Kenya and of the southernmost corner of coastal Somalia, where living Achatinas are frequent and the forest–savannah mosaic vegetation type [Bonnefille, R., 1985. Evolution of the continental vegetation: the palaeobotanical record from East Africa. South African Journal of Science 81, 267–270] is widespread. According to radiometric ages of *Achatina* shells and geological observations, aridification process probably took place in the Late Holocene. Somali data are consistent with the known regional climatic trends.

Keywords: Holocene; Somalia; *Achatina*; Rhizoliths; Radiometric ages; Aridification

1. Introduction

1.1. Foreword

The Holocene climate was globally highly variable, with periods of rapid, dramatic change (Mayewski et al., 2004). Regional climatic trends are influenced by topographical pictures and local circulation pattern; they can be fairly revealed only by a really well distributed records.

In East Africa, which shows a great diversity in climates mainly linked to topographical features, the most important evidence for the Holocene climate change is provided by the past lake-level fluctuations in the Ethiopian Rift Valley and pollen diagrams from inner mountainous areas; no paleoclimatic data are available for the coastal belt for the entire Holocene.

This paper discusses the presence of subfossil giant land snail *Achatina* and of rhizoliths in the coastal dunes of southern Somalia; they can be used as a paleoclimatic proxy, confirming the climate deterioration occurring in the East-African region after the Mid Holocene.

1.2. Regional Mid-Late Holocene climate record

The entire Afro-Asian northern monsoonal belt underwent an increasing aridification process during the Late Holocene (Hoelzmann et al., 1998; Gasse, 2000; Lückge et al., 2001; Nicoll, 2004). At Mid to Late Holocene transition, the climatic trend to modern pattern started as a consequence of changes in monsoon intensity and atmospheric circulation patterns (Kutzbach and Street-Perrot, 1985; Kutzbach and Liu, 1997). During the Mid-Holocene the Inter Tropical Convergence Zone (ITCZ) was shifted northward and the summer monsoon humid air masses moved with greater intensity as is observed today (Gasse and Van Campo, 1994; Rodriguez et al., 2000; Lückge et al., 2001; Gasse, 2002). In most of tropical Africa, rainfall began to decrease after 5.8 kyr BP (deMenocal et al., 2000; Gasse, 2000), in apparent association whit a northern

---

[*] Corresponding author. Tel.: +39 0 649914789; fax: +39 0 64454729.
E-mail address: ruggero.matteucci@uniroma1.it (R. Matteucci).

1464-343X/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jafrearsci.2007.07.001

deglaciation event (Stager et al., 2003); the pronounced shifting to drier environmental conditions, recorded in many sites between 5 and 3 kyr BP (Bonnefille and Chalié, 2000), was centered about 4 kyr BP (Marchant and Hooghiemstra, 2004). The aridification process was oscillating and highly unstable, with short-term drying events (Bonnefille and Mohammed, 1994; Gasse, 2000; Schilman et al., 2001).

In the northern tropics of Sudan and Egypt the increased aridity after 5–4.5 kyr BP contributed to the demise of the Old Kingdom in the Nile valley (Hassan, 1997; Salzmann and Waller, 1998; Gasse, 2002; Nicoll, 2004); an abrupt drying event at 4 kyr BP is related to the collapse of Mesopotamian civilization (Cullen et al., 2000); a dramatic break was observed at about 3.5 kyr BP in India (Caratini et al., 1994); in coastal Pakistan (Rad von et al., 1999), precipitation decreased after 4.0–3.5 kyr BP; in Madagascar, the first major change in vegetation as a consequence of natural dessication is placed about 3 kyr BP (Burney, 1993; Matsumoto and Burney, 1994).

In East Africa, the climatic stepover began relatively abruptly at around 4.5–4 kyr BP (Maitima, 1991; Beuning et al., 1997; Barker et al., 2000; Benvenuti et al., 2002; Dramis et al., 2003; Lamb et al., 2004); in the last 3 kyr BP, pollen diagrams register significant climatic changes in south-eastern Ethiopia, with a cooler climate following the colder and humid phase of Mid-Holocene times, a drier period between 1.8 and 0.95 kyr BP and major climatic variations in the last millennium (Bonnefille and Mohammed, 1994; Machado et al., 1998).

2. Modern environmental setting

2.1. Physiography and geology

The coast of southern Somalia is characterized by the presence of the "Merka red dune", an ancient dune ridge, running parallel to the coast and separating a narrow coastal strip from the alluvial plain of the Shabelle river (Fig. 1). The river flows perpendicularly from the inner mountains to the coast, turning southwards and running along the coast from Muqdishu to the village of Gelib, where it is incorporated into a marshland, usually without reaching the sea.

The "red dune" is a siliciclastic polyphase complex, whose width ranges from 8 to 10 km south of Muqdishu to 100 km north (Carbone et al., 1984; Angelucci et al., 1995). Its maximum height is about 150 m a.s.l., near the town of Merka. On the east side, the dune partly overlies a coral-rich marine sequence which outcrops along the shore; on the western side, the dune underlies the Shabelle alluvial deposits (Fig. 4). Wide mobile quartz dunefields lie on the ancient "red dune". In the narrow coastal strip, there are well developed white mixed quartz–carbonate dunes, lying on the marine carbonate substrate or on the eastern side of the "red dune". The innermost mixed quartz–carbonate dunes are richer in quartz grains than the coastal ones and show a yellow-brown colour, mainly due to the persistent lateritic coatings of some quartz grains. Quartz granule content varies from 40% to 60% in weight of the innermost white dunes or of the recent deposits due to deflation of the old "red dune" to 15–20% of the present-day beach. North of Muqdishu, most of the white dunes are almost completely made of quartz granules of aeolian and fluvial origin (70–80% in weight). Mineralogical composition of the red dune is mainly siliciclastic: 79–85% quartz grains, 16–25% feldspar and accessory minerals, 2–3% carbonate grains (Angelucci et al., 1995 and unpublished data). Only some of the mostly coastal white dunes are stabilized by vadose cementation. Long axes of both red and white dunes run essentially parallel to the coast (Fig. 1).

The recent carbonate dunes of the African coast of the Indian Ocean were formed during the post-glacial sea-level rise (Illenberger and Rust, 1988; Carbone et al., 1999), mainly after the sea-level bypassed the edge of the continental shelf, about 8 kyr BP, according to Hopley (1994) and Ramsay and Cooper (2002). Carbonate grains (miliolids and other foraminiferids, small bioclastic fragments) for the Somali white dunes were supplied by the skeletal sandy beach and coral reefs bounding the coast on the seaward side; skeletal grains were blown off the beach by the coastwise directed summer monsoon. A progradation of the coast occurred during the marine regression to the present sea-level, after the sea reached a higher level of about 2 m a.s.l., around 5 kyr BP (Jerardino, 1995; Carbone et al., 1999; Carbone and Accordi, 2000; Teller et al., 2000; Ramsay and Cooper, 2002). The "red dune" and the white dunes of the innermost part of the coastal strip are now subject to deflation and remodelling.

2.2. Climate and vegetation

Climate of southern Somalia is semi-arid or arid, with a bimodal rainfall distribution, influenced by monsoonal winds. The main rainy season is between March and June, centered on April–May ("Gu" season, in Somali). The second, less abundant and more variable rain season is between September and November ("Der" season; "Jilal" and "Hagai" are the dry seasons, in Somali). However, along the coast, the Jilal season is rainy, so there is a unique rainy season from March to September, entirely regulated by the SW monsoonal wind (Fig. 2); its core is in June and its 300–600 mm/yr abundance (Kismayu station, Fantoli, 1960) decreases from south to north; on the Kenyan border, the annual rainfall even reaches 600–700 mm/yr. If we take a mean monthly rainfall of 50 mm as the limit between dry and humid months (Rizzo, 1977), only in the southern corner along the coast the wet season is longer than three months without interruption (Fig. 2c and d, Kysmayu and Muqdushu stations, after data in Fantoli, 1960).

Insolation is very high, with a long dry season from November to May. The annual mean temperature is of 26–27 C°, with low seasonal fluctuations.