Journal of African Earth Sciences 112 (2015) 163–185

Contents lists available at ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

An integrated study of the *Homo*-bearing Aalat stratigraphic section (Eritrea): An expanded continental record at the Early–Middle Pleistocene transition

Massimiliano Ghinassi [a, *], Oriol Oms [b], Mauro Papini [c], Fabio Scarciglia [d], Giorgio Carnevale [e], Federico Sani [c], Lorenzo Rook [c], Massimo Delfino [e, f], Marco Pavia [e], Yosief Libsekal [g], Luca Bondioli [h], Alfredo Coppa [i], David W. Frayer [j], Roberto Macchiarelli [k, l]

[a] Dipartimento di Geoscienze, Università di Padova, Via Gradenigo, 6, 35121 Padova, Italy
[b] Dpt. de Geologia, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain
[c] Dipartimento di Scienze della Terra, Università di Firenze, Via G. La Pira, 4, 50121 Firenze, Italy
[d] Dipartimento di Biologia, Ecologia e Scienze della Terra (DiBEST), Università della Calabria, Via P. Bucci – Cubo 15B, 87036 Arcavacata di Rende, CS, Italy
[e] Dipartimento di Scienze della Terra, Università degli Studi di Torino, Via Valperga Caluso, 35, 10125 Torino, Italy
[f] Institut Catala de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Edifici Z (ICTA-ICP), Carrer de les Columnes s/n, Campus de la UAB, E-08193 Cerdanyola del Valles, Barcelona, Spain
[g] National Museum of Eritrea, P.O. Box 5284, Asmara, Eritrea
[h] Sezione di Bioarcheologia, Museo Nazionale Preistorico Etnografico 'Luigi Pigorini', P.le G. Marconi 14, 00144 Roma, Italy
[i] Dipartimento di Biologia Ambientale, Università di Roma 'La Sapienza', P.le A. Moro 5, 00185 Roma, Italy
[j] Department of Anthropology, University of Kansas, 626 Fraser Hall, Lawrence, KS 66045-2110, USA
[k] Département de Préhistoire, UMR 7194 CNRS, Muséum national d'Histoire naturelle, Palais de Chaillot, 17 Place du Trocadero, 75116 Paris, France
[l] Département Géosciences, Université de Poitiers, bât. B35 Sciences Naturelles, 86073 Poitiers, France

ARTICLE INFO

Article history:
Received 14 August 2015
Received in revised form
16 September 2015
Accepted 16 September 2015
Available online 25 September 2015

Keywords:
East Africa
Pleistocene
Sedimentology
Magnetostratigraphy
Paleopedology
Fossil vertebrates
Paleoanthropology
Paleoenvironments
Dandiero
Danakil

ABSTRACT

The Early to Middle Pleistocene continental transition in East Africa is widely documented from lacustrine and deep-sea records, although significant insights are also provided by fluvio-lacustrine successions of the central and southern African Rift Valley, such as the at Olduvai Gorge succession (Tanzania), the Bouri Formation (Ethiopia) and the Olorgesailie Formation (Kenya). The Early to Middle Pleistocene Dandiero Basin fill (Eritrean Danakil) represents the only continental succession in the northernmost sector of the African Rift Valley that provided abundant fossil vertebrates, including human remains. The present study integrates already available data with new sedimentological, pedological, magnetostratigraphic, paleontological and paleoanthropological investigations of the 300 m thick Aalat section (North Dandiero Basin). This sedimentary succession records repeated shifts from fluvial to lacustrine depositional settings, which occurred under the tight interaction between local tectonics and Pleistocene climate changes. Accumulation was associated with axial sedimentation in a NS-trending extensional basin, with an overall tectono-sedimentary setting comparable with that of the coeval Bouri Formation (Ethiopia). Because of the high rates of sedimentation, a poor to moderate degree of soil development characterizes the whole succession. Sporadic soil horizons testify to carbonate dissolution, leaching and accumulation in calcic and petrocalcic horizons (indicating an overall dry climate). The alternate with local to extensive iron-oxide/hydroxide segregation, promoted by water infiltration under varying drainage conditions and/or seasonal contrast, that record more humid conditions. Magnetostratigraphic dating and correlation indicates that this section is among the world's thickest record embracing the Early-Middle Pleistocene transition, spanning from the Jaramillo to the base of Brunhes chron. The terrestrial vertebrate fauna includes a typical Early to Middle Pleistocene East African mammalian assemblage for this age and is dominated by taxa characterized by strong water dependence. The ichthyofauna, with its abundant Clariidae, is also consistent with the shallow water, fluvio-lacustrine

* Corresponding author.
E-mail address: massimiliano.ghinassi@unipd.it (M. Ghinassi).

http://dx.doi.org/10.1016/j.jafrearsci.2015.09.012
1464-343X/

paleobiotopes. The cranial, dental and postcranial human remains from the lower part of the Aalat succession add valuable evidence about the patterns of variation and evolutionary dynamics in African *Homo erectus/ergaster* near the end of the Early Pleistocene.

1. Introduction

Plio-Pleistocene environmental dynamics of the East Africa Rift have been widely documented from lacustrine and deep-sea records (e.g., deMenocal, 1995, 2004; Magill et al., 2013; Maslin et al., 2014). In this region, the Plio-Pleistocene environmental instability triggered main ecological changes, which in turn, influenced the patterns of mammal diversification, dispersal and turnover (Bobe and Eck, 2001; O'Regan et al., 2005, 2006, 2011; Fernández and Vrba, 2006; Patterson et al., 2014) and likely also hominin evolution (Behrensmeyer, 2006; Bailey and King, 2011; Potts, 2013; Antón et al., 2014). Although lacustrine and marine records are noticeably continuous, fluvio-lacustrine continental successions also provide significant insights into paleoecological and geomorphic dynamics (Brown et al., 1992; Katoh et al., 2000; WoldeGabriel et al., 2005; Aronson et al., 2008).

Environmental and faunal variations during the Pliocene and Early Pleistocene are well-known from continental successions of Ethiopia and Kenya (Behrensmeyer et al., 1997; Trauth et al., 2007; Ashley et al., 2009). A discontinuous record characterizes the Early-Middle Pleistocene transition, which included a series of significant abiotic and biotic events, such as the onset of 100 kyr glacial cycles (Kingston, 2007) and the increase of the geographic range of *Homo erectus* s.l. (Antón, 2013). The most studied Early to Middle Pleistocene continental deposits of East Africa (Fig. 1A) developed in extensional basins along the African Rift Valley and include the Olduvai Bed II and IV of the Olduvai Gorge succession (Domínguez-Rodrigo et al., 2013), in Tanzania, the Daka Member of the Bouri Formation (Gilbert and Asfaw, 2008), in Ethiopia, and the Olorgesailie Formation (Owen et al., 2009), in Kenya.

In the northernmost sector of the African Rift Valley, the only outstanding continental succession of the Early-Middle Pleistocene transition, which provided abundant vertebrate and human remains is located in the Dandiero Basin (Fig. 1A and B), along the Eritrean Rift margin (Abbate et al., 2004). The basin fill is characterized by a complex stratigraphic architecture due to lateral and vertical stacking of fluvial and lacustrine deposits (Abbate et al., 2004).

This paper focuses on the 300 m thick fluvio-lacustrine Aalat succession, located in the northern part of the Dandiero Basin, where a nearly complete adult human cranium was found in 1995 (Abbate et al., 1998). Here, we introduce new significant advances to provide an integrated review of the sedimentological, magnetostratigraphic, pedological, paleontological and paleoanthropological record from the Aalat succession and compare it with coeval fossiliferous succession along the African Rift Valley. The sedimentary succession is studied through principles of facies analyses and paleopedology, and different deposits are ascribed to specific depositional environments. New magnetostratigraphic analyses were carried out in order to provide a high resolution time control for the main environmental shifts.

2. Geological setting

The Danakil depression is located at the northern edge of the Afar region (Fig. 1), and runs in a NNW-SSE direction for ~ 300 km, widening towards the south up to approximately 13° North. The continental Eritrean-Ethiopian plateau delimits the Danakil depression to the west, whereas the northeastern margin is constituted by the Danakil block. The southern termination of the depression is marked by the alignment of the Quaternary Mahalta-Afrera volcanic centers (Fig. 1B). The Danakil depression developed since the Middle Miocene (Eagles et al., 2002) as a consequence of the continental crust thinning. The sediments filling the Danakil depression mainly consist of Plio-Pleistocene marine evaporitic deposits and onlap the Eritrean-Ethiopian plateau escarpment and the Danakil horst, unconformably covering the Palaeozoic–Mesozoic sedimentary units, as well as the Precambrian basement.

The Dandiero Basin is located 35 km south of the Gulf of Zula (Fig. 1B), along the N-S trending western marginal graben system of the Danakil depression (Abbate et al., 2004). In particular, the Dandiero basin is controlled by two main roughly NNW-SSE trending, east dipping normal faults. The westernmost fault delimits the basins from the plateau, whereas the easternmost marks the limit between the basin succession and the Samoti Plain (Fig. 1C). Moreover, the succession is affected by many small faults that can be grouped into different systems. The two most represented fault systems are generally NE–SW and NW–SE oriented and are either synthetic or antithetic in relation to the two major east-dipping faults, whereas the minor systems are N–S and E–W oriented. In general, the vertical throw of these faults does not exceed a few tens of metres, and only two fault systems show an overall higher displacement. The first one, located on the eastern side of the study area, shows a NE–SW trend and lowers the southwestern hanging wall of about 100 m. The second fault system, NW–SE trending, is located slightly south of Mt. Alat, shows a displacement of about 25 m and dips down the northern block.

The sedimentary succession filling the basin (Fig. 1C) has been referred as the Dandiero Group (Abbate et al., 2004; Ghinassi et al., 2009; Papini et al., 2014). In the type area, the Dandiero Group is about 1000 m thick and incorporates fluvial, transitional (deltaic), lacustrine and alluvial fan sediments. The significant unconformities recorded in the Dandiero sedimentary succession allow a partition in terms of unconformity-bounded stratigraphic units (Synthems): Maebele Synthem (Early to Middle Pleistocene), Curbelu Synthem (Late Pleistocene) and Samoti Synthem (Late Pleistocene to Holocene) composed of alluvial deposits and aeolian sands. The Maebele Synthem is divided into in six formations (Abbate et al., 2004; Papini et al., 2014): fluvial Bukra Sand and Gravel, fluvio-deltaic Aalat Formation, fluvial Wara Sand and Gravel, lacustrine Goreya Formation, fluvio-deltaic Aro Sand and alluvial Addai Fanglomerate. Palaeomagnetic analyses, mammal biochronology and radiometric dating (Ferretti et al., 2003; Albianelli and Napoleone, 2004; Bigazzi et al., 2004; Martínez-Navarro et al., 2004; Ghinassi et al., 2009; Rook et al., 2010, 2013) highlight that the Jaramillo Subchron is recorded in the upper part of the Bukra Sand and Gravel and lower part of the Aalat Fm. The transition from the Matuyama to the Brunhes Chron occurs close to the base of the Aro sand.