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Journal of Archaeological Science 34 (2007) 1011–1015

Journal of Archaeological SCIENCE

http://www.elsevier.com/locate/jas

Monuments on a migrating Nile

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Received 6 June 2006; received in revised form 6 September 2006; accepted 7 September 2006

Abstract

River courses migrate, but many Egyptologists plot the present-day River Nile on maps of the valley in archaeological times. This may have misled interpretations of ancient monuments and settlements. We show a river migrating rapidly on historical timescales in the Luxor region, sweeping > 5 km across the valley at rates on the order of 2–3 km per 1000 years. Satellite elevation data (SRTM), processed by a novel method, and Landsat imagery are used to trace ancient river levees and extend trends present in 200 years of archive maps thousands of years into the past. This supplements observations by Ptolemy (121–141 AD) and places local geo-archaeological studies in a wider spatial and temporal context. Satellite data are demonstrated to be a relatively quick and easy constraint upon ancient river courses, and a basis for investigations along the Egyptian Nile, even in logistically inaccessible regions.

Keywords: Nile; SRTM topography; Egypt; Course migration

1. Introduction

1.1. Geological context

Carved into the African Plateau ~ 5–8 million years ago and then mostly re-filled with sediment, the ~ 10 km wide Nile Valley is cliff-bounded and flat-bottomed (Attia, 1954; Butzer, 1980; Said, 1993). From 200,000 years ago, a transition began to the present regime of arid climate and a summer flood (Butzer, 1976, 1980), leaving a river with no significantly active Egyptian tributaries. So, the Nile is a constrained and relatively simple river. Many Egyptologists plot the present-day River Nile on maps of archaeological times (Aufrère 1991; Baines and Malek, 2002), probably because the exact nature of the Nile's movements remains poorly known. This is likely to be a simplification and may have misled interpretations of ancient monuments and settlements.

1.2. River migration

It has long been known that the Nile migrates. St. Pachomius founded a monastery on the island of Tabenna in the 4th century (323 AD) "*but the shifting course of the river has long since annexed the island to the mainland*" Butler (1884). However, in ~ 920 km of the Egyptian Nile Valley (Attia, 1954), such migration and its relationship to archaeological sites remain sparsely studied.

Between 124 and 141 AD, Claudius Ptolemaeus (a.k.a. Ptolemy) astronomically located 54 currently identifiable Nile Valley sites (Memphis to the Great Cataract at 21°50′N) and described their position relative to the river (Ball, 1942). By placing Ball's (1942) reconstruction onto modern cartography, Butzer (1976) highlighted a predominantly eastward river migration since Hellenistic times. Extrapolating back, Butzer labelled the postulated course of the Ptolemaic river "*probable axis of dynastic (2950–332 B.C.) Nile*".

Butzer (1976) verified his observation using maps (1798 AD to recent) and satellite photography, in a 70 km stretch of the valley north of Sohag (~26°30′N, 31°40′E), finding

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doi:10.1016/j.jas.2006.09.011

11 of 17 bends moving east. Unfortunately, even here, his much-reproduced cross-section (Baines and Malek, 2002) (vertical transect showing sub-surface structure across the valley) must extrapolate between 6 boreholes (Attia, 1954) in a 70 km by 10 km area and generalise migration rates.

Most recently, the two local geo-archaeological studies to have considered river migration in the Nile valley proposed eastward migration at Memphis (Jeffreys, 1985) but westward drift at Luxor (Graham and Bunbury, 2005). This paper seeks to reconstruct a continuum of past meanders and investigate the apparently anomalous behaviour near Luxor, starting with observations from 0 to 200 BP (before present).

2. Method

Maps from the last 200 years are used to establish the rate at which the river's course has migrated, and the directions of the movement. Interpreted in this context, the satellite-observed landscape is then used to extend trends thousands of years into the past.

Satellite derived elevation data (Satellite Radar Topography Mission, or SRTM) (NASA, 2004) are a regularised lattice, or grid, with 3 arc-second resolution. Namely, each 90 m by 90 m rectangular area of land has a single measured height representing it. When the SRTM data are sampled (linear interpolation) at the locations of 67 valley-floor spot-heights on modern survey maps (Egyptian General Survey Authority, 1991), the r.m.s difference is 1.9 m (2 s.f.); a measure of the accuracy of the SRTM data. A regional vertical shift of −2.7 m from map to SRTM data is also present, due to differences in the reference geoid used. So levees, typically 1–3 m high (Egyptian General Survey Authority, 1991), are potentially resolvable. However, the down-river slope of the valley floor across the studied region (Fig. 1) is 3–4 m. Processing is therefore necessary to account for relatively large-scale 'regional' trends such as these.

SRTM data are processed by locally evaluating upper and lower envelopes around the data, and then displaying the topography according to colour scale stretched between these limits. Specifically, processing of topography uses a 1 km × 1 km sliding window, returning the evaluated number to a central point (`grdfilter` of the GMT software package; Wessel and Smith, 1998). Initially, smoothed topography is produced by a sliding window returning a median, then upper and lower envelopes are the highest and lowest points in windows passed across the smoothed topography. Unprocessed SRTM topography, smoothed by 400 m wide Gaussian-weighted sliding-window filter to reduce measurement noise, is then coloured by a scale stretching between the envelopes (Fig. 2). Landsat imagery is also enhanced; details in Fig. 1.

3. Results

3.1. Maps: motions 0–200 years BP

Maps produced since the 1897–1907 survey of Egypt are based upon a full triangulation network and astronomical

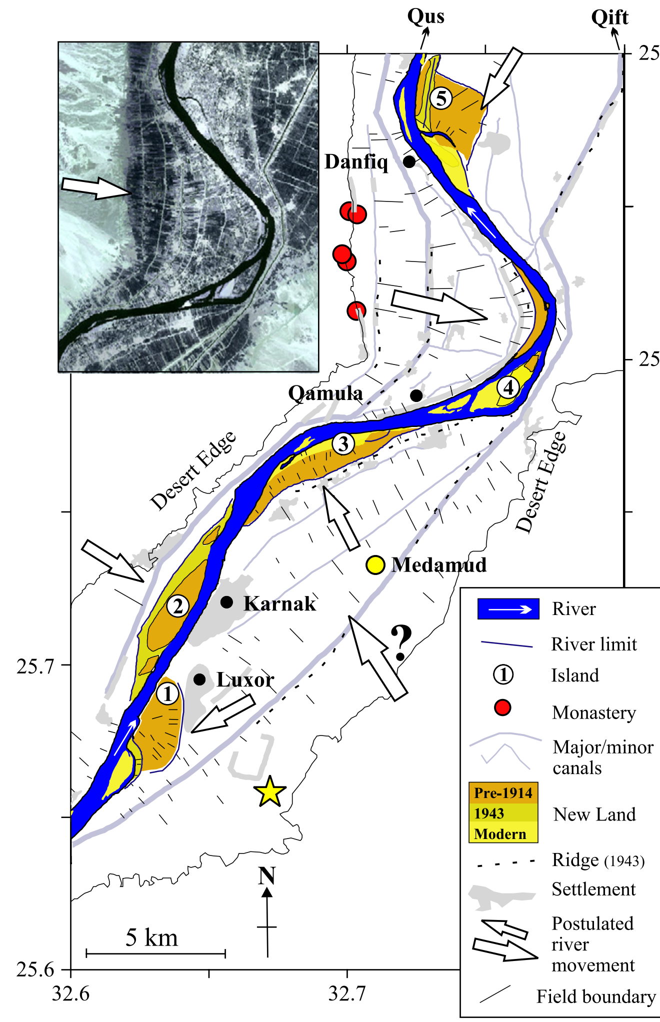

Fig. 1. Summary of the river migration preserved in accurate modern-style survey maps (1914, 1:50,000 (Survey Department, 1914); 1943, 1:25,000 (Department of Survey and Mines, 1943); 1991, 1:50,000 (Egyptian General Survey Authority, 1991)) in the Luxor region of the Nile valley. Annotations on the bounding box are longitude and latitude in decimal degrees. For orientation, modern settlements and selected canals are also shown. Migration directions (arrows) are estimated from newly made land (sandy shades) and old river boundaries (thin dark-blue lines). Inset is a Landsat image (spectral bands for r, g, b triplet are 7, 3, 5), enhanced by locally equalising the intensity contrast, a standard image processing technique. Local equalisation, by pulling the lightest grey towards white and the darkest towards black, which causes all grey shades (black to white) to be utilised within each sub-region of the image. Spatial resolution is 28.5 m. For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.

data, and can be regarded as accurate (Ball, 1942). Modern river behaviour (Fig. 1) validates and underpins our interpretation of more ancient times. The behaviour is deduced from a time-series of maps published in 1914 (Survey Department, 1914), 1943 (Department of Survey and Mines, 1943) and 1991 (Egyptian General Survey Authority, 1991). River, island and side-channel locations are used to deduce where new land has been created during each time-step as islands form and old channels silt up. Islands, "*Jazirat*" or "*Geizret*" in Arabic, named on the maps but drawn annexed to the mainland, (1–3 and 5 in Fig. 1) also indicate the direction in which the river's course has moved.