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## DATA PAPER

# A Database of Radiocarbon Dates for Palaeoenvironmental Research in Eastern Africa

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Radiocarbon dating is one of the most widely available and applied techniques to develop Late Quaternary chronologies of many ecosystems and is, thus, utilized in Quaternary studies, archaeology, hydrology, geomorphology, palaeoanthropology, palaeoclimatology, palaeoecology, palaeontology, and isotope analyses. A manual literature review search of published radiocarbon dates from eastern Africa was undertaken to store these data in the open-access format and included in the Canadian Archaeological Radiocarbon Database. Dates ranged from 57,804 to 0 <sup>14</sup>C years Before Present. The format of the database permits expansion of the dataset in the future and permits local, regional and global scale analyses of radiocarbon dates. This paper expands on some of these potential research areas and promote archiving of African data.

**Keywords:** Accelerator mass spectrometry; Africa; archaeology; carbon isotopes; chronostratigraphy; depositional systems; geochronology; palaeoanthropology; palaeoecology; palaeoclimate; sedimentary systems

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## (1) Overview

### Introduction

Increasingly, the ecological palaeoecology approach (Birks 2012; Rull 2014) is being applied to provide long-term contexts to modern ecological, human-environment interaction, conservation studies and land management policies (Willis & Birks 2006; Gillson & Marchant 2014). Geochronological information is critical to understanding past changes in ecosystem compositions and distributions, landscape ontogeny, and to characterize historical baselines of variability to inform management, conservation, and remediation efforts. Geochronological information permits analyses of the variability and rates of change to Earth system processes, including climate, ecosystem changes, evolution, phylogenies, and constraining the interactions between ecosystems and human modifications, across multiple spatiotemporal scales. Radiocarbon dating is one of the most widely available and applied techniques to develop Late Quaternary chronologies of many ecosystems (Libby 1946; Arnold & Libby 1949; Libby et al. 1949; Anderson & Libby 1951; Trumbore 2000) and is, thus, utilized in Quaternary studies, archaeology, hydrology, geomorphology, palaeoanthropology, palaeoclimatology, palaeoecology, palaeontology, and isotope analyses.

Within these scientific disciplines, radiocarbon dates are often reported alongside publication literature but

have only recently begun to be collated into regional (Fyfe et al. 2008; Gajewski et al. 2011) and global databases (Gajewski et al. 2002, Marchant et al. 2002; Gajewski 2008; Grimm 2008; Power et al. 2008). Data repositories improve accessibility for research across multiple disciplines and to other interested groups outside of academia (Brewer et al. 2012; Grimm et al. 2013). Additionally, databases are useful as educational and professional training tools (Courtney Mustaphi et al. 2014; Goring et al. 2015). An accessible archive of published radiocarbon dates from eastern Africa is necessary for robust syntheses of multi-site and large spatial scale analyses of palaeoenvironmental sites (Daniau et al. 2010), data-model intercomparison (Braconnot et al. 2012; Marlon et al. 2015), and to provide a tool for investigating past human demographics (Gayo et al. 2015; Chaput et al. 2015). Empirical data of past environmental conditions are a critical resource for constraining model outputs of projected future change within the Earth system.

### Context

#### *Spatial coverage*

Depositional environments in eastern Africa.

Description: Burundi, Egypt, Ethiopia, Kenya, Tanzania, and Uganda, Malawi, Mauritius, Mozambique, and the Gulf of Aden.

Northern boundary: 22.692141  
 Southern boundary: -22.231519  
 Eastern boundary: 57.518249  
 Western boundary: 29.083309

### Temporal coverage

The spread of radiocarbon dates ranged from 57,804 <sup>14</sup>C yr BP to modern radiocarbon ages (1950 common era; 0 calibrated years BP). BP, before present.

## (2) Methods

A manual literature search was conducted and published radiocarbon dates were entered from palaeoenvironmental studies, including palaeoclimatological, palaeoecological, environmental archaeology and palaeontological sources. Dates were collected from geologic (carbonaceous sediments, plant macroremains); anthropogenic (hearths, fire pits, and pottery); and faunal remains (eggshell, bone, dung). Other sources of dated material are noted in the data files. Dates from study sites required published coordinates and details pertaining to common radiocarbon dating reporting, such as laboratory code identifiers, radiocarbon ages and errors (Stuiver & Polach 1977; Van der Plicht & Hogg 2006; Millard 2014).

### Steps

The vast majority of dates were entered in the database manually from tables in published literature or data sources. The data upload template has minimum requirements, including the identifier code supplied by the laboratory, the material dated, geographic coordinates, and the radiocarbon age with associated 1 $\sigma$  dating error.

Conforming to CARD criteria, publications that did not present radiocarbon laboratory identification codes were assigned as 'LUNK-000' or 'LLUNK-000' that can be updated in the future (n = 6). In cases where the  $\delta^{13}\text{C}$  values were not recorded alongside radiocarbon dates (n = 392), the values were estimated as: -27‰ for peat, bulk sediment, picked organic samples, and dung; -25‰ for wood and charcoal; -10‰ for bone apatite; and 0‰ for marine shells and foraminifera. These values can also be updated if needed and are noted as assayed, estimated, or measured. Modern radiocarbon dates were inputted as 0 $\pm$ 0 <sup>14</sup>C yr BP and users are referred to the data source reference.

### Sampling strategy

### Quality Control

Used the data input template (version 1.3; 29 September, 2015) of the CARD 2.0 database.

### Constraints

## (3) Dataset description

Radiocarbon dates (n = 793) were tabulated primarily from geologic settings (n = 763), archaeological (n = 23) and palaeontological (n = 7). Sixty eight study sites were examined encompassing 70 published papers. Modern

radiocarbon dates were assigned as 0  $\pm$  0 <sup>14</sup>C yr BP (n = 21). The majority of geological dates were from Kenya and Tanzania (**Fig. 1**). Most of the dates obtained were from the late Holocene (**Fig. 2**). Dates were dominantly from studies of lacustrine and palustrine sediments and fewer dates from soil, cave, fluvial or marine depositional settings. Dated samples of biogenic material such as charcoal and bone that were manipulated by human agency were assigned as archaeological. Faunal remains that were naturally deposited were classified as palaeontological.

### Object name

CARD2.0 database:

CARD\_Upload\_Template\_-\_KITE\_East\_Africa\_v1.0.xlsx

Harvard Dataverse:

Courtney Mustaphi, Colin, 2016, "Radiocarbon dates from eastern Africa in the CARD2.0 format", <http://dx.doi.org/10.7910/DVN/NJLNRJ>, Harvard Dataverse, V5

### Data type

Collated secondary data with references to publication sources.

### Format names and versions

MS Office 2010 Excel file (.xlsx) and identical version as a .csv file (Courtney Mustaphi, 2016).

### Creation dates

The data was collated in this format beginning 30 August 2015 and ended 6 February 2016.

### Dataset Creators

Colin J. Courtney Mustaphi, researcher, University of York.

### Language

English.

### License

The dataset is available from Harvard Dataverse under a CC0, Public Domain Dedication. The CARD database version requires registration and webpage login for access as part of the global database.

### Repository location

Canadian Archaeological Radiocarbon Database (CARD version 2.0) (Morlan, 1999) <http://www.canadianarchaeology.ca/>

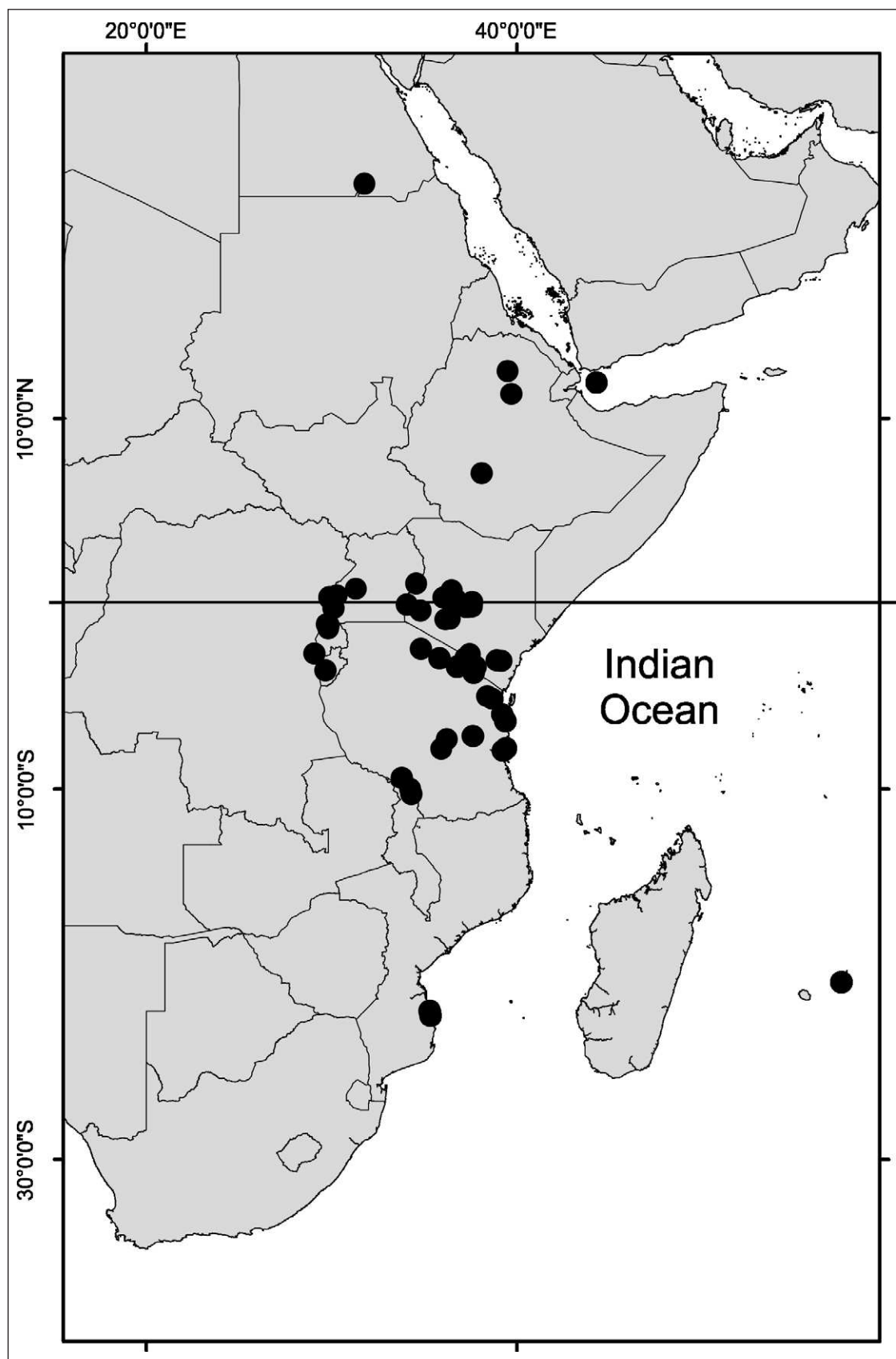
Duplicate deposited to the Harvard Dataverse (Courtney Mustaphi 2016) <http://dx.doi.org/10.7910/DVN/NJLNRJ>

### Publication date

16-03-2016

## (4) Reuse potential

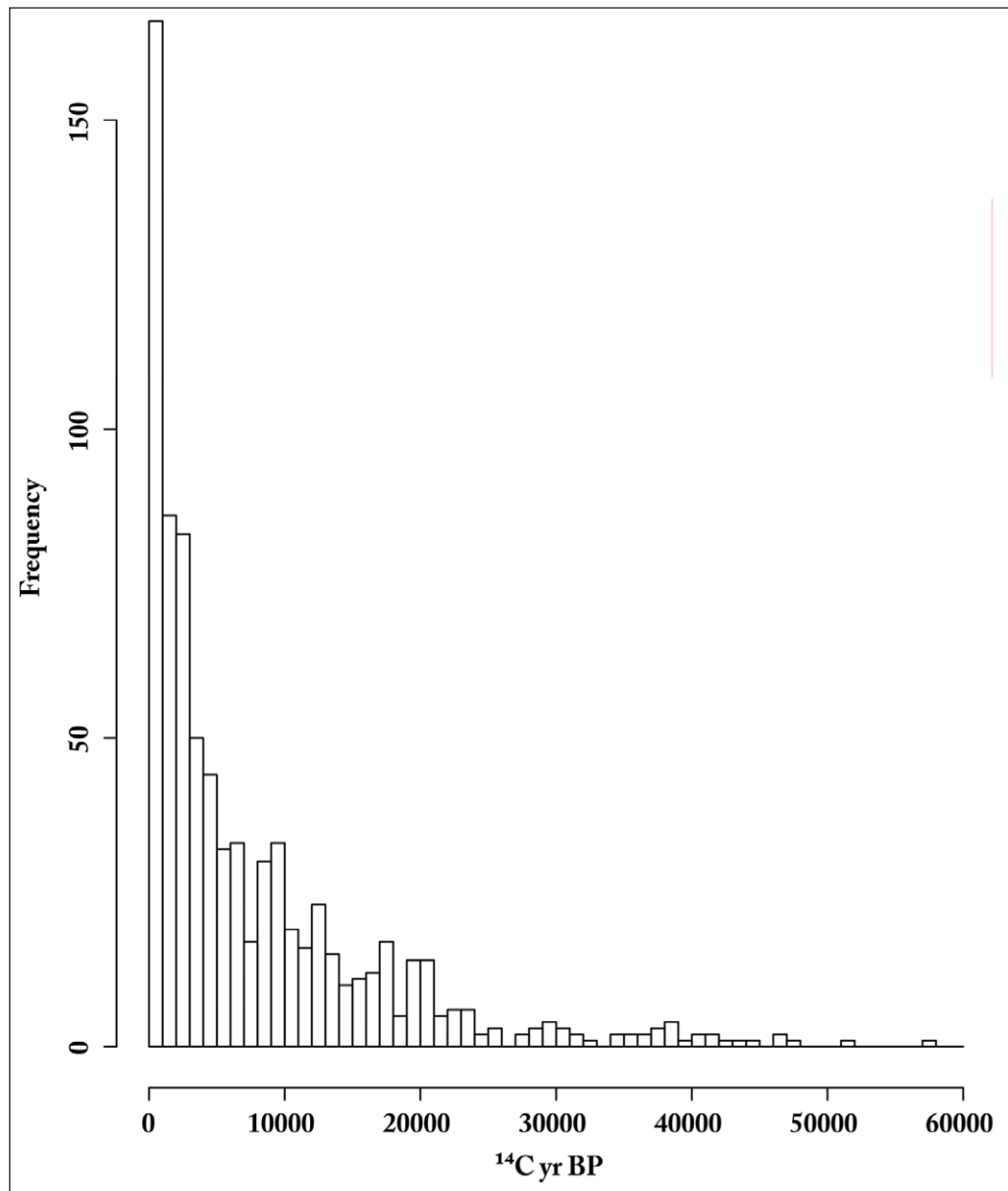
The Canadian Archaeological Radiocarbon Database (CARD) was developed as a repository and database for querying archaeological, geologic and paleontological sites and is now a global database (Morlan 1999). An East African Radiocarbon Database developed at York



**Figure 1:** Map of eastern Africa and the locations of published radiocarbon dates presented in the dataset.

Institute for Tropical Ecosystems has been formatted to port into CARD2.0. It is freely available at <http://www.canadianarchaeology.ca>. Extremely few radiocarbon dates from Africa are stored within available databases (Chaput

& Gajewski in press) and most dates pertain to cultural artefacts and not environmental sources that are useful for palaeoenvironmental and palaeoecological querying. Here we present nearly 800 reported radiocarbon dates



**Figure 2:** Histogram of uncalibrated radiocarbon dates in the dataset in 1000-year bins.

from eastern Africa, primarily derived from palaeoecological studies and encourage expansion by the palaeoecological, palaeontological and archaeological research communities with an interest in African climate, ecology, people and landscapes.

These data were compiled as part of ongoing work to collect palaeoenvironmental proxy data from study sites across eastern Africa and formatted to be shared via the global CARD database and website interface. This is especially important as few radiocarbon dates from Africa are readily available and here we present an initial fraction of the published dates from Africa. The database can be expanded as additional researchers contribute. These data can be used to examine environmental patterns of change across the region in the past (McClure 1976), including erosion and sediment accumulation rates (Goring et al. 2012; Crann et al. 2015), and past demographics using dated cultural material (Chaput et al. 2015). Sediment

accumulation rates in fragmentary and non-sequential depositional systems, such as fluvial, colluvial, and turbidite environments may need further scrutiny due to the complexity of reworking, depositional hiatus, and instantaneous events (Chiverrell et al. 2009). Furthermore, caveats have been identified for the use of radiocarbon dates as potential proxies of ancient population numbers and this remains an active topic in archaeology (Shennan et al. 2013; Timpson et al. 2014; Attenbrow & Hiscock 2015; Brown 2015). Individual studies will require scrutiny of the radiocarbon data applied to investigate past demographics and substantiate the use of such proxy data (Torfing 2015). Palaeoenvironmental data continues to be accrued into various repositories and databases but all rely on baseline geochronological data. To improve reproducibility and data sharing, we suggest explicit presentation of stratigraphic and geochronological controls in papers so that age-depth models can be reconstructed.

We present the CARD2.0 database as a useful and readily accessible repository for radiocarbon age determinations from studies in Africa and hope to expand upon these initial samples with further effort in the research community for open-access use. It is foreseeable that there will be increasing global requirements for data-based and referenced palaeoenvironmental data from multiple user groups across multiple disciplines in ecology, conservation, land management, policy, palaeoecology, environmental modeling, anthropology, archaeology, sedimentology, geochronology and education (Kriegel et al. 2010; Brewer et al. 2012; Marchant and Lane 2015).

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#### Competing Interests

The authors declare that they have no competing interests.

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