

# A Late Holocene $\delta^{18}$ O paleoclimate record from the afro-alpine Lake Garba Guracha, Bale Mountains Ethiopia: implications for human occupation/abandonment TECHNISCHE UNIVERSITÄT A Late Glacial and Holocene $\delta^{18}$ O paleoclimate record from the afro-alpine Wulf Lake, Bale Mountains Ethiopia \*Samuel Getachew Chernet (1), Lucas Bittner (1), Graciela Gil-Romera (2,3), Wolfgang Zech (4) and Michael Zech (1)

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## 1. Introduction

The socio-economic framework of East Africa region is tied to the availability and sustainability of water resources. Long and short term climate variabilities can disrupt the delicate water balance in different reservoirs, often leading to prolonged drought and famine. Understanding the past climate variabilities and their influence on hydrological dynamics is a crucial step towards successful forecasting and mitigation.

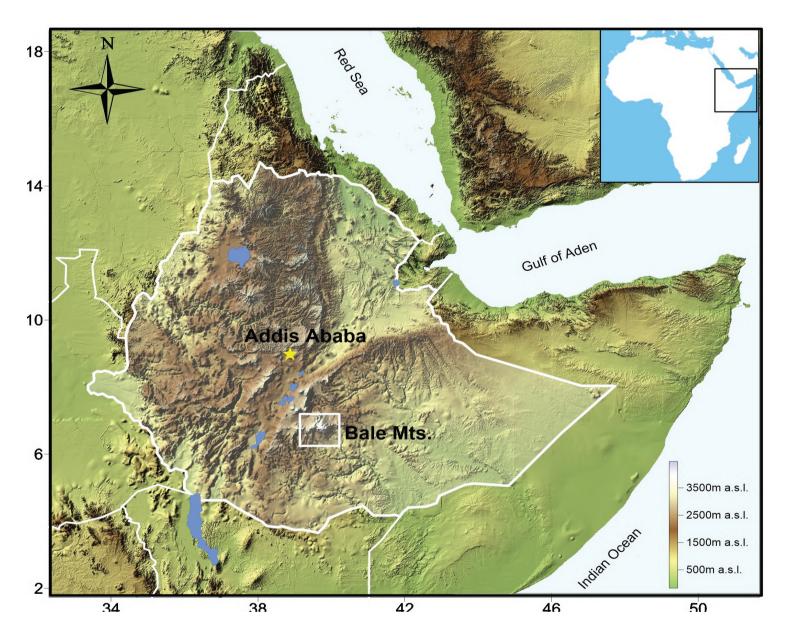
The Bale Mountains, part of the southeastern Ethiopian highlands, hold one of the best climate archives of the Afro-alpine ecosystem in Africa [1,2,3]. It's also one of the few mountain ranges that were glaciated during the last Glacial Maxima [4,5]. Small lacustrine and peat deposits were formed as a result of glacial retreat (16.7 cal kyr BP) in the depressions of Sanetti Plateau [6]. Under DFG funded (DFG Research Unit 2358) The Mountain Exile Hypothesis project, several studies have been conducted in an effort to understand these climate archives using different proxies [eg. 1,2,3,6,7,8].

δ<sup>18</sup>O<sub>sugar/diatom</sub> study in the neighboring Lake Garba Guracha [1] proved to be the best proxy to reconstruct the 12000 year paleoclimate history of the region. The aim of this study is to apply this proxy to Wulf Lake to extend the record to Late Pleistocene.

## 2. The Study area

The study area is located 400km south East of Addis Ababa (capital of Ethiopia), in the Bale Mountains National Park (39° 28' -39° 57' E and 6° 29' - 7° 10' N).

It's the largest alpine ecosystem in Africa and contains the country's second largest peak Mount Tulu Dimtu (4377 m a.s.l.) [8].



Wulf Lake, located on the Sanetti Plateau of 4126m a.s.l. has an area of 219x593m.

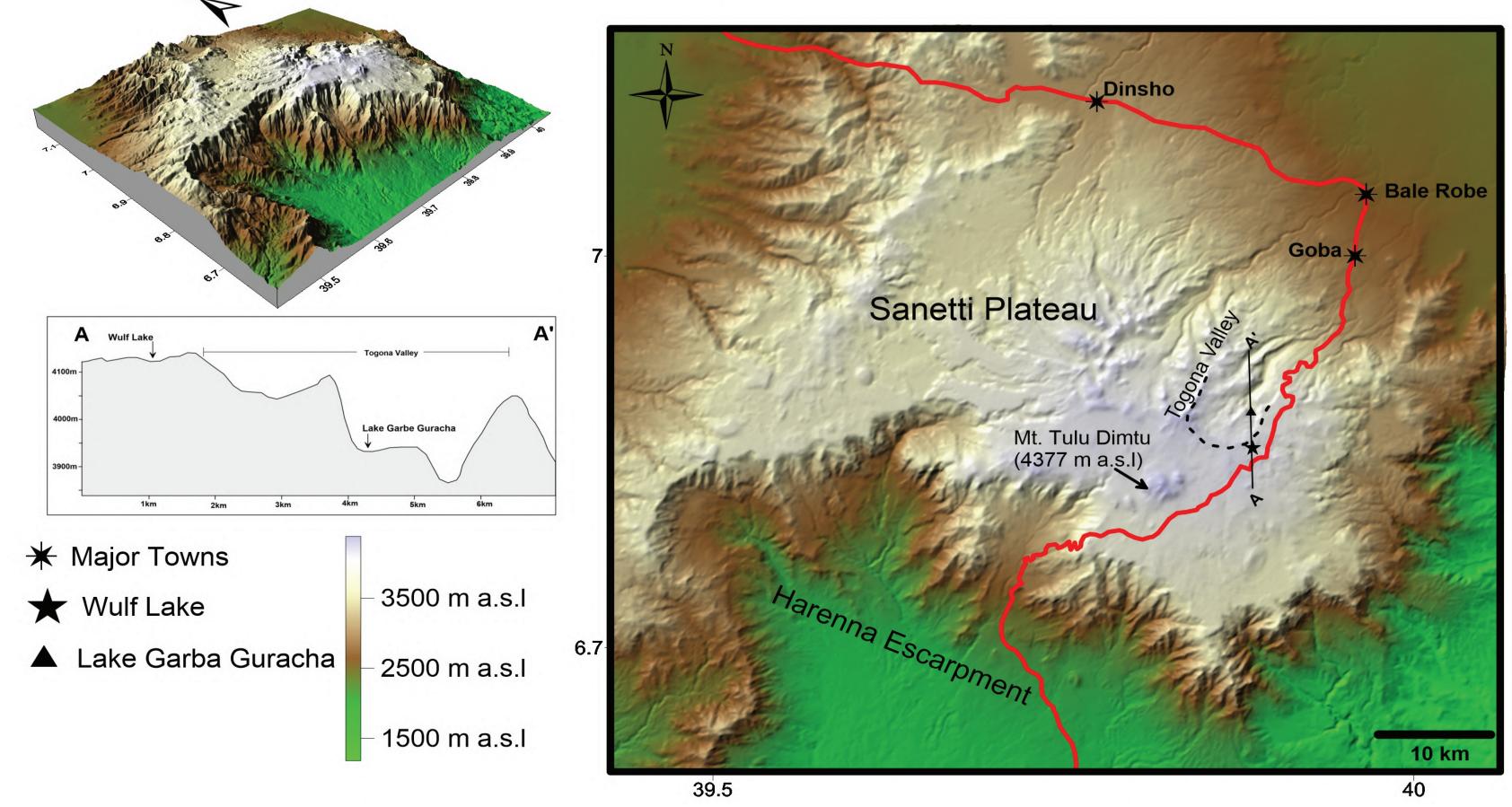


Figure 1. Physiographic make up and location map of the study area

### 3. Objectives

- Reconstruct the paleoclimate history of Wulf Lake by analyzing the isotopic signature of monosaccharide sugars (Arabinose, Fucose and Xylose)
- Investigate millenial to centennial scale variations in the record and the possible presence/absence of influences of major regional and global climate events such as the the African Humid Period, Younger Dryas and local humid/dry phases.

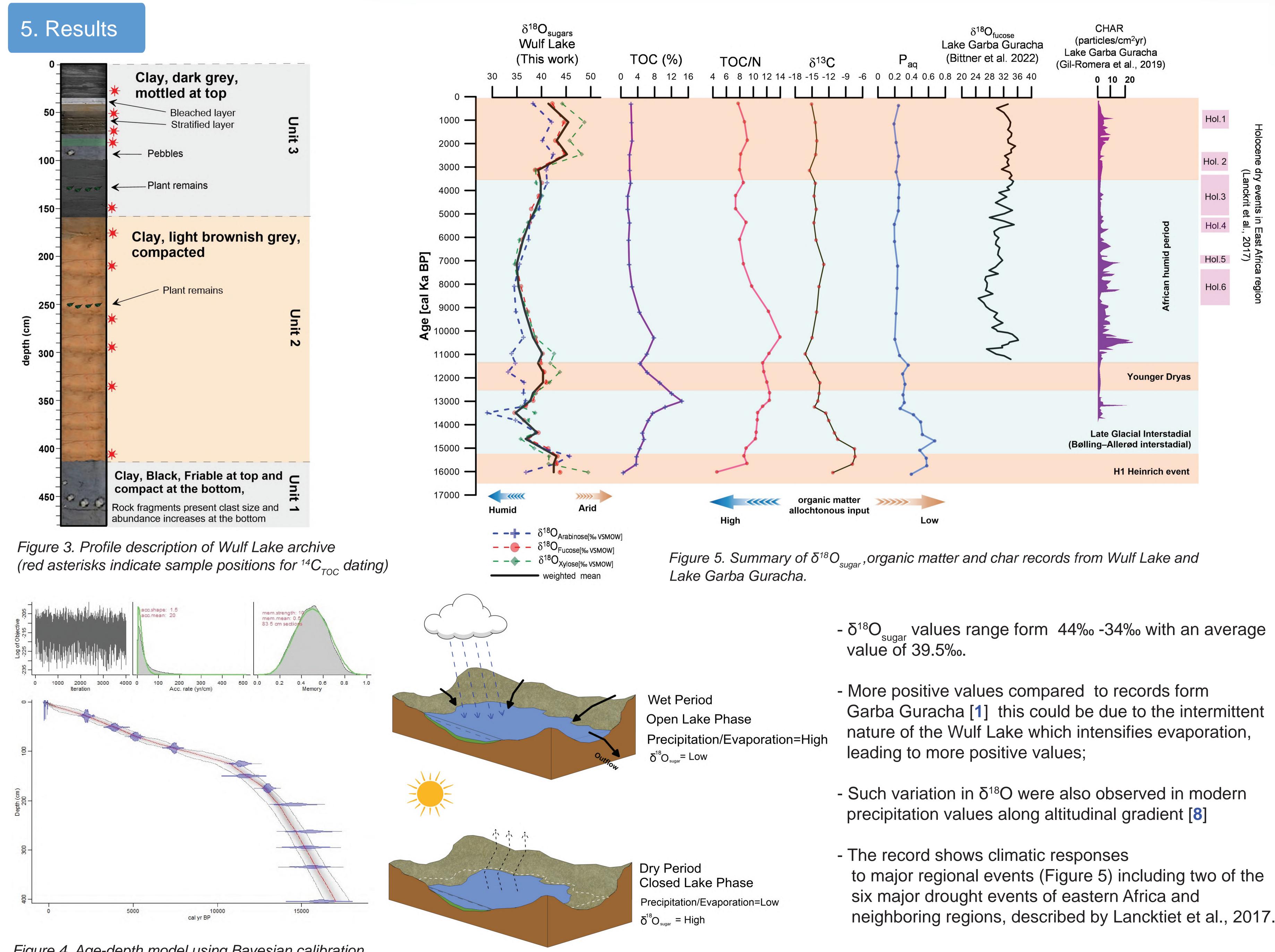
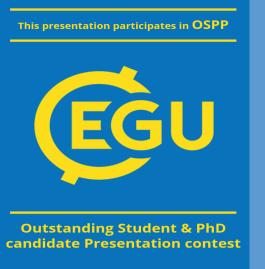


Figure 4. Age-depth model using Bayesian calibration in Bacon package Rstudio (2023.03.0)

Figure 6. Conceptual model demonstrating  $\delta^{18}O_{sugar}$  variations during wet and dry phases of the lake

- to major regional events (Figure 5) including two of the neighboring regions, described by Lancktiet et al., 2017.





4. Methodology
Extraction
- Hydrolysis (4 M trifluoroacetic acid at 105°C for 4 hours)
- Filtration using glass fiber filters (to remove inorganic fractions)
- Filtration using XAD-7 and DOWEX 50WX8 columns (100-200 mesh size)
(to separate monosaccharides form other organic and/or soluble compounds)
2 Preparation
- Derivatization of monosaccharide sugars at 60°c for 1 hour
(Addition of methylboronic acid (MBA) inhibits oxygen addition via acetylation during analysis.)
3 Analysis
- Measurements were done on a Trace GC 1310 and Delta V Advantage IRMS
- Samples remeasured in triplicates to insure robust results
<ul> <li>Results are corrected for amount dependency and instrument drift and are presented in δ notation vs. VSMOW</li> </ul>
1.2 1.1- 1.0-
0.9- 2 2 0.8-
6000- 5000- 5000-
$\frac{4000}{\Sigma}$
ara Myo-ino Rhm (internal std)
Figure2. GC chromatogram (Ara: Arabinose, Fuc: Fucose, Xyl: Xylose,
Rhm: Rahmnose, Myo: Myo-inositol)
6. Summery and Outlook
<ul> <li>Stable oxygen isotopic records of monosaccharide sugars in Wulf Lake archive, coupled with generally low amount of TOC/N <sup>13</sup>C and P values.</li> </ul>
archive, coupled with generally low amount of TOC/N <sup>13</sup> C and P <sub>aq</sub> values, indicate hydrologic changes mainly driven by climate shift of the
Late Glacial and Holocene.
- Despite having higher values, climate records of the Holocene are in
agreement with records of Lake Garba Guracha.
- Overall, study of stable isotope form monosaccharide sugars prove to be
valuable in paleoclimate study
What's Next?
Can the story of $\delta^{18}$ O records be corraborated by other proxies
such as $\delta^2 H_{n-alkanes}$ ?
7.References
[1] Rittpor at al. 2021 [2] Rittpor at al. 2020 [2] Cil Romara at al. 2010

[1] Bittner et al., 2021 [2] Bittner et al., 2020 [3] Gil-Romera et al., 2019 [4]Ossendorf et al., 2019 [5] Groos et al., 2021 [6] Mekonnen et al., 2022 [7] Lemma et al., 2019 [8] Lemma et al., 2021 [9] Lancktiet et al., 2017