Holocene climate reconstructions from western Anatolia based on speleothem data

Reporting

Project Information

SPELEOTOLIA

Grant agreement ID: 842403

Project website

DOI
10.3030/842403

Project closed

EC signature date
2 April 2019

Start date
2 May 2019

End date
1 November 2021

Funded under
EXCELLENT SCIENCE - Marie Skłodowska-Curie Actions

Total cost
€ 157 355,52

EU contribution
€ 157 355,52

Coordinated by
MIDDLE EAST TECHNICAL UNIVERSITY
Türkiye

Periodic Reporting for period 1 - SPELEOTOLIA (Holocene climate reconstructions from western Anatolia based on speleothem data)

Reporting period: 2019-05-02 to 2021-05-01

Summary of the context and overall objectives of the project

Anatolia served as a crossroad for early human migration and was a key-region for the spread of agriculture into Europe and the development of major empires such as the Hittite and Ottoman. An in-depth understanding of Holocene climate variability in Turkey is thus critical to investigate to what extent climate has shaped major evolutionary and cultural transformations in the region.

Main goal of this MSCA-IF project (host institution: METU) is to identify the driving factors of Holocene climate variability in western Turkey and its possible impacts on ancient civilizations, and to distinguish potential anthropogenic signatures in stalagmites. Specific research objectives are: 1) to select the best speleothems from the target caves and to establish a high-precision chronological framework using U-Th dating, 2) to reconstruct high resolution stable isotope (O, C) and trace element time series controlled by robust geochronology, 3) to investigate the stalagmite-forming CO2 degassing system in detail by combining geochemical signals of drip water/host rock/stalagmites and stalagmite microtextural characteristics, and 4) to constrain the geochemical signature of possible anthropogenic signals.

This project develops precisely-dated and highly resolved (annual to multi-decadal) records of rainfall (and temperature) from the Sırtlanini Cave (western Turkey) covering the last ~6000 years for western Turkey, and possibly for the Eastern Mediterranean region.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

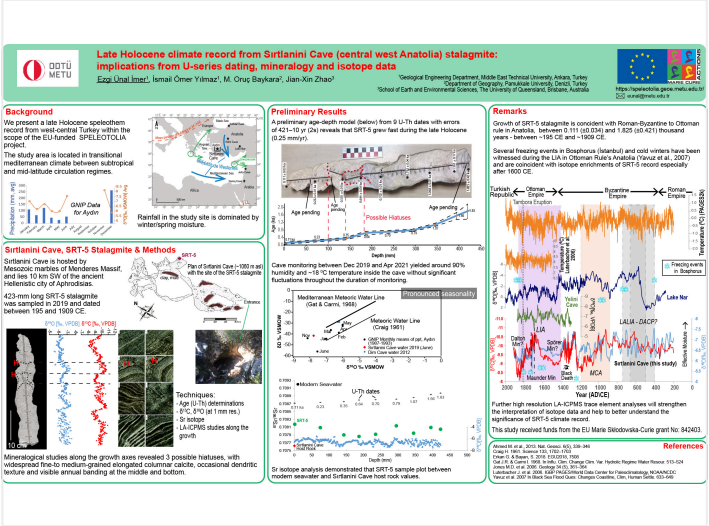
Throughout the project timeline covering the work packages (WP) 1 to 7, an exhaustive dataset was generated through a multi-proxy approach of isotope and trace element geochemistry using Holocene-aged (U-Th geochronology) stalagmites. Also, the WPs concerning the ethics requirements (D1.1 D1.2 and D 1.3) and the data management plan (DMP) have been provided.
The beneficiary set up a METU-hosted project website (WP1-D1) and developed a detailed budget plan (D2) for the research to implement the project. Project management/monitoring continued for the entire time span of the project and budget planning was established during the first two months.
Field studies (WP2), aimed collection of speleothems, cave water, and host rock samples, were carried out in June–July 2019. The list and photographs of the visited sites are available on the project website. As previously provided through the D 1.2 all permits for research in caves were obtained prior to the fieldwork. Further, as provided with D 1.3 all necessary measures were taken regarding health and safety throughout field studies.
Target caves visited from and nearby archeological sites (e.g. one near Sırtlanini Cave) were explored in collaboration with local archeologists and ministry personnel. A total of 18 stalagmite, 6 host rock and 4 water samples were collected (D3). Cave monitoring was performed in the Sırtlanini Cave for one year, where most suitable stalagmites were collected from (D3).
A total of 26 microsamples (from 10 stalagmites) were sent to the University of Queensland-UQ (Australia) for the first set of geochronological analyses (WP3-D4 and MS1). In the mean time, four cave water samples were sent to MERLAB (METU) for water isotope (H and O) analyses. After receiving initial age data from UQ, two Holocene-aged stalagmites were selected for detailed

geochemical and geochronological analyses based on the research budget. Together with water isotope and age results, first interpretation phase of the project was completed (WP4).
During WP5, high-resolution microsampling was performed on selected stalagmites (D5) and microsamples were sent to laboratories for high-resolution stable isotope, high frequency dating, Sr isotope and LA-ICP MS trace element analyses (MS2). This work package was interrupted by a 6-month-long amendment due to COVID-19 pandemic, between May–November 2020. Retrieved monitoring indicated limited variation in temperature (~18 0C) and ~90% humidity (WP2). Since the laboratory analyses were postponed due to COVID-19 regulations both in Australia and Turkey, complete analytical data was received late during WP7. This limited the time allocated for the second interpretation phase. One stalagmite (SRT-5) from Sırtlanini Cave was examined in detail for reconstruction of climate between ~1800–111 years before present-BP, covering the Roman-Byzantine and Ottoman Rule in Anatolia. Reconstructed isotope profile revealed isotopic enrichments coincident with severely cold winters during the Little Ice Age at the time of Ottoman Rule. Another stalagmite SRT-4 grew between 5733- and 577-years BP, showing isotopic anomalies during the 3.2 ka event. Petrographic analyses were performed on both samples (D6). Finally, high resolution trace element analyses and Hg analyses were obtained from SRT-5 to explore possible sources of trace elements and anthropogenic signatures, distinguishing between natural and human-related tracers. Manuscripts (MS3 and MS4) presenting project findings and interpretations focusing on distinct climate change periods (e.g. 3.2 ka event and Little Ice Age) are currently in preparation and will be submitted to open access journals.
Communication strategies (C1–C3) of the project have been fulfilled by publication of the project website (C1), public engagements with the local authorities (C2), and by a two-day international workshop (entitled “Advances in Karst Research”) (C3) at the 23rd month of the project. Further public outreach activities included an interview for the Horizon Magazine (March 2020) and invited talks in May 2021 and November 2020.
At the end of the project, 3 conference papers were published (vEGU2021 poster is attached), 2 journal papers are in preparation, 1 online Horizon Magazine story was published, and 2 invited talks were delivered. The conferences, online story, key analytical findings, and workshop talks are shared through the project website. The beneficiary also participated to an online Turkish interview on a science channel “BolBilim” on Youtube in March 2021.

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

This MSCA-IF project studied hydroclimatic conditions of the Holocene Anatolia using new paleoclimatic records gathered from speleothems. Out of six Holocene samples, two Sırtlanini Cave stalagmites were analysed in detail for obtaining a high-resolution multi-proxy dataset. Examining entire growth of SRT-5 stalagmite by ultra-high-resolution trace element analyses enabled to reconstruct the paleorainfall histories between ~195 CE and ~1909 CE. New SRT-5 record will be a milestone focusing especially on the Little Ice Age period. Moreover, both SRT-4 and -5 stalagmites were examined using medical CT-Scan methodology for their internal structures along with detailed thin section studies under the microscope. These studies showed annual growth conditions in line

with changes in high-resolution stable isotope and trace element time series. This project developed new records that can be correlated with other well-known speleothem and lake records in the Eastern Mediterranean to explore regional Holocene climate conditions and present new implications towards late Holocene human activities against changing environment.
Finally, the newly-generated datasets with detailed data descriptions will be contributed to online open databases such as NOAA and reported via open research journals for researchers to make regional comparisons and use in model-proxy correlations for future climate predictions.



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Last update: 15 February 2022

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