Ancient TL

www.ancienttl.org · ISSN: 2693-0935

Ancient TL, 2022. *Thesis Abstracts.* Ancient TL 40(2): 11-13.
https://doi.org/10.26034/la.atl.2022.563

Thesis Abstracts

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Harriet Cornachione

Holocene Chronostratigraphy of Dune Fields in Southern Utah: Geomorphic Record of Past Aridity in the Central Colorado Plateau

August 2022

Utah State University, Logan, United States

Degree: Ph.D.

Supervisor: Dr. Tammy Rittenour

The Southwestern United States has a semi-arid climate and is currently in a hydrologic drought that exceeds in magnitude and duration any period of drought in at least five centuries. Evidence of past migrations by Indigenous communities and the appearance/rise of other cultural adaptations in the archaeological record during previous episodes of aridity provide warning of similar disruption in modern times. This is especially of concern given that climate models predict conditions of aridity in this region will be exacerbated in the future due to anthropogenic climate change. Better understanding of the natural variability of hydroclimate will inform both adaptive strategies for future climate change and improved climate forecasts. While instrumental records only span the last < 100 years, paleoclimate archives (i.e., tree-rings, sediment deposits) can provide longer duration records that provide a baseline for the frequency and magnitude of past aridity.

This dissertation investigates two dune fields on the central Colorado Plateau in southern Utah. A chronostratigraphic record of eolian activity is developed to determine periods of dune-field activation as an indicator of hydroclimate conditions during the Holocene. Methods and datasets used in this research include geomorphic mapping, descriptions of stratigraphy and sedimentology, optically stimulated luminescence and radiocarbon dating, geochemical analysis of sediments and analysis of regional wind data.

The Kanab dune field in southwestern Utah is a largely stable dune field with parabolic dunes of 2 – 15 m in height. The dune field is oriented roughly west to east. Chronostratigraphic records were used to identify five periods of dune-field wide eolian activity: K0 (~ 9.2 – 7.8 ka), K1 (~ 6.8 – 5.6 ka), K2 (~ 4.4 – 3.3 ka), K3 (~ 2.2 – 1.2 ka) and K4 (~ 0.7 – 0.4 ka). Activity events occur at millennial intervals, and coincide with Bond events and other global climate records, suggesting a climate driver. The San Rafael dune field in east central Utah contains thin (2 – 6 m tall), east-northeast trending dune forms, partially stabilized with soil biocrusts and xeriphytic shrubs, with sections of currently active parabolic dunes and smaller barchan dunes and dune fields. Seven episodes of eolian activity were determined from chronostratigraphy in the dune field: SR0 (~ 17 – 16.2 ka), SR1 (~ 12.4 – 11.2 ka), SR2 (~ 9.7 – 7.4 ka), SR3 (~ 4.7 ka), SR4 (~ 3.4 – 2.5 ka), SR5 (~ 2.0 – 1.6 ka) and SR6 (1.1 – 0.4 ka). Thin deposits and discontinuities in the record suggest an erosion-dominant landscape. Results from both dune field indicate three periods of coeval dune activation in the two dune fields at ~ 9.5 – 7.5 ka, ~ 2 – 1.5 ka, and ~ 1 – 0.5 ka. These are interpreted to record periods of regional aridity. Records of mobile dune activity from other sites across the Colorado Plateau suggest at least three and as many as five periods of regional dune activity interpreted to be related to regional aridity.

Analysis of weather station data indicate that modern wind regimes are consistent with dune field orientation, suggesting they are a useful analog for Holocene winds. Analysis of dune sediment geochemistry using K/Rb-K/Ba suggests that the sediment source material did not change between periods of dune activation. This result supports interpretation of a climate driver for dune field (re) activation events and not changes in sediment supply.

A PDF of this thesis can be downloaded from: https://doi.org/10.26076/606f-c35f

Michael Hein

Beyond the trenches – A landscape-oriented chronostratigraphic approach to MIS 5 Middle Paleolithic open-air sites on the European Plain. Case studies from Lichtenberg and Khotylevo I

November 2021

Max Planck Institute for Evolutionary Anthropology (MPI EVA), Department of Human Evolution, Leipzig, Germany

Degree: Ph.D.

Supervisors: Prof. Jean-Jacques Hublin (MPI EVA); Dr. Tobias Lauer (MPI EVA); Dr. habil. Hans von Suchodoletz (Leipzig University)

The research presented in this thesis aims to establish robust chronostratigraphic frameworks for Late Pleistocene Neanderthal open-air sites on the European Plain, because

well-dated occupations are largely missing so far beyond the range of radiocarbon. It is argued that a firm chronological and stratigraphic foundation is the prerequisite for understanding Neanderthal behavior and its potential synchronization with environmental or climatic events. Only that way, behavioral traits can be inspected in terms of adaption to corresponding developments and changes. This is trying to be illustrated by conducting case studies at Khotylevo I, Western Russia and Lichtenberg, Northern Germany at opposite ends of the European Plain. Very deliberately, the surroundings of these sites were included into the consideration. These can provide insightful background information, which help to better decipher site formation processes and may also elucidate Neanderthal habitat preferences. The two study sites share many similarities, concerning their northern locations, the stratigraphic potential of their embedding sediment sequences and their artifact assemblages, dominated by *Keilmessers*. The latter are asymmetrical, bifacial backed knives, usually made from flint and they represent the type tools for the late Middle Paleolithic period in Central and Western Europe. While for both sites, previous chronological data rather support an assignment to MIS 3, the characteristics of their deposits also made an earlier occupation in MIS 5a seem possible. This ambiguity was to be resolved using geomorphological surveys, pIRIR290 luminescence dating on potassium feldspar (ca. 30 samples) and sediment analyses, the latter also including palynology for additional environmental context. The chronostratigraphic results led to a revision of the timing for the occupations at the two sites: In Khotylevo I it happened during MIS 5a and in Lichtenberg at the MIS 5a/4 transition. The new ages are consistent with the stratigraphic and paleoenvironmental findings and are therefore considered robust and reliable. They provide evidence for an emergence of the *Keilmessergruppen* before the onset of the first glacial maximum in MIS 4, which had been a matter of debate so far. The MIS 5a/4 occupation in Lichtenberg further demonstrates Neanderthal capability to cope with severely cold conditions that could be reconstructed for that phase on site.

The landscape-oriented approach of the investigations directly resulted in the discovery of two hitherto unknown occupations at the site of Lichtenberg. The first one could be allocated to the Mid-Eemian Interglacial (Pollen Zone E IVb/V), the second one was dated and palynologically assigned to the late Brörup Interstadial (ca. 90 ka, Pollen Zone WE IIb). Since the artifacts from these two fully-forested intervals differ from the later *Keilmesser*-dominated artifact assemblages considering shape, size and tool variability, it is proposed that changing environments co-determined the lithic technology.

Chronostratigraphic achievements also include i) the first comprehensive chronology for the widespread 2nd fluvial terrace (MIS 5b to MIS 3) on the Russian Plain, ii) a first numerical age for the termination of the Brörup Interstadial (ca. 90 ka) in its type region, and iii) the first detection of climatic fluctuations during the MIS 5a/4 transition on the European Plain (correlated with Greenland Interstadials GI-20 and GI-19). These findings will help to better contextualize contemporaneous archaeological sites in the wider region.

A PDF of this thesis and the three included journal articles can be downloaded from: https://www.researchgate.net/profile/Michael-Hein-8

April I. Phinney

Investigating the Use of Quartz Luminescence and Rock-Color Alteration to Characterize Wildfire Exposure; Applied to the 2020 Mangum Fire, Kaibab Plateau, Arizona

December 2022

Utah State University, Logan, United States

Degree: M.Sc.
Supervisor: Tammy Rittenour

Wildfires appear to be increasing in size, severity, and frequency. Land managers need information on past wildfire behaviour to make effective and adaptive land management plans. However, there are only a few techniques and data sources that provide information on past fire heating. This study aims to provide new methods to equip managers with a more robust understanding of historic and modern fire behaviour. Fire behaviour is assessed using novel methods that can assess soil and rock response to past wildfire heat exposure.

This study examined samples from the 2020 Mangum Fire, in northern Arizona. Sediment and rock were gathered to characterize past fire heating. These samples come from sites with differing soil burn severity (which is a measure of how much the vegetation at the soil surface was destroyed by fire) within the Mangum Fire burn region and sites from outside the fire perimeter.

Luminescence (light) emitted from quartz minerals was analysed following three methods in the lab to detect past heat exposure. Thermally altered rock color (reddening) was also used to assess past heating. This study demonstrates that luminescence signals and rock color measurably alter when heated. These methods may be able to characterize past wildfire heating and provide a more detailed characterization of past fire behaviour. Understanding the difference between past and present fire characteristics can equip land managers to better steward complex ecosystems and the role of fire within these communities.

Alexander Short

Late Pleistocene Piedmont Records in the Grand Staircase Region, Southern Utah

December 2022
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Degree: M.Sc.
Supervisor: Tammy M. Rittenour

Undifferentiated Quaternary alluvial gravel deposits cap sections of the benches of the Grand Staircase in southwestern Utah. Geomorphic position and stratigraphic description suggest these deposits represent the remnants of abandoned piedmont systems and associated terrace sediments deposited during the Pleistocene. Research focuses on the influence of climate and geomorphic processes on late Pleistocene landscape evolution of the Grand Staircase region of southern Utah using piedmont deposits within the five adjoining study catchments as markers of past hillslope sediment supply and river incision. The study catchments are tributaries to the Colorado River and have gradients with base level being controlled by Grand Canyon. The primary hypothesis is that piedmont gravel deposition is driven by climate change and that deposit ages correspond to transitions between glacial and interglacial conditions. Investigation and correlation of piedmont deposits is based on geomorphic analysis, and detailed outcrop and facies descriptions of the sedimentology, stratigraphy, and soil profile development. Age control is provided by optically stimulated luminescence (OSL) dating of representative deposits in each of the study catchments. Deposits of this nature can present a unique set of challenges for OSL dating. Therefore the character of these deposits required the implementation of various sampling techniques.

OSL dating results suggest at minimum three synchronous periods of deposition across the region during the Late Pleistocene (53 ka to > 268 ka) separated by periods of pronounced incision. Accommodating variability between drainage basins, Quaternary alluvial pediments (Qap) can be divided as follows. Qap3 deposits lie 95 to 170 m above the modern channel and were deposited 115 to > 192 ka. Qap2 deposits lie 60 to 75 m above the modern channel and were deposited 69 to 103 ka. Qap1 deposits lie 15 to 25 m above the modern channel and were deposited ~ 53 ka. Secondary, younger and conformable, depositional periods are marked by buried soil horizons identified within Qap3 and Qap2 deposits. A broad comparison of the timing of deposition to regional climate records suggests a response to climate to be the dominant process of Quaternary aggradation and incision of fluvial systems and overall landscape evolution.

A PDF of this thesis can be downloaded from: https://digitalcommons.usu.edu/etd/8651/

Angeli Vasiliki

Dosimetric characterization of new materials with thermally and optically stimulated luminescence for radiation dosimetry

April 2022
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Degree: M.Sc.
Supervisors: Professor George Kitis and Dr. George S. Polymeris

This doctoral dissertation is related to a qualitative as well as a quantitative correlation among Thermoluminescence (TL), Blue Optically Stimulated Luminescence (Blue OSL) and Infrared Stimulated Luminescence (IRSL), for different natural dosimetric materials. The geological materials that were used are, a) natural fluorite, CaF_2: N, b) gypsum, c) Durango apatite with two different grain size factions and d) three different K-feldspar samples with code name, ELD1, VRS3 and MRK4; each one belonging to the structural group of microcline, sanidine and orthoclase. The above minerals have been selected due to their specific luminescence characteristics. This work consists of three experimental parts: The first one is attempting the correlation between specific TL glow curves and bleaching components after LM-OSL as well as Blue CW-OSL stimulation, in the case of natural fluorite. The second part includes three materials, Durango apatite, gypsum and one K-feldspar. This part is studying the correlation between the Blue CW-OSL as well as the Residual LM-OSL signal. A two-step stimulation protocol was applied including 10 different IRSL stimulation times, from 0 to 500 s. Finally, the third part is describing the correlation of Blue CW-OSL and IRSL properties of three K-feldspar samples. The stimulation was carried out using Blue CW-OSL and IRSL in two different two-step experimental protocols. The complexity of both recombination pathways as well as the efforts to correlate among the aforementioned luminescence signal was highlighted in the present work.