**Workshop Ramosch Lab Abstracts**

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## From colonization to control and creation of value: a diachronic view on prehistoric cycles of development in the Alpine area

1. Introduction: Cycles of Alpine colonization and settlement

Alpine colonization and settlement does not appear as a continuous evolutionary process, but rather as a series of individual periods or cycles of varying length and intensity, at least if we use information on find density, site frequency and human impact on landscape (e.g. from palynology) as proxies for settlement history and intensity (Della Casa 2000). Typically, a first Mesolithic cycle differentiates from a (yet fairly unknown) Neolithic one, followed by a Copper Age (the time of the Iceman), a Bronze Age and eventually an Iron Age settlement cycle. The question that arises is: Are these cycles historical realities or constructs of the research status, and if real, how can the cyclical variations be explained?

2. Theoretical models borrowed from economic history and eco-dynamics research

Questioning the state of research is a necessary but daring undertaking that requires a lot of energy, in particular in areas where systematic data survey is difficult to achieve. However, recent regional studies such as in the Leventina valley CH (Della Casa 2018) or Silvretta massif A-CH (Reitmaier 2017) seem to confirm the view of cyclical trends. For this paper, we propose to follow a model of "adaptive cycles" derived from the comparative study of the dynamics of ecosystems, as proposed by C. S. Holling (2001): "It focuses attention upon processes of destruction and reorganization, which are often neglected in favor of growth and conservation. Including these processes provides a more complete view of system dynamics that links together system organization, resilience, and dynamics."

3. Triggers and drivers of developmental cycles: climate, innovation, and societal changes

Climate changes (in particular climate crises), economical developments (e.g. the advent of metallurgy) and societal changes (demographic growth, hierarchies) are often cited as triggers and drivers of non-linear developments. However, none of them can be viewed as an individual decisive factor since adaptive cycles are driven by complex system dynamics. The term "Panarchy" has been re-coined to describe such evolving hierarchical systems with multiple interrelated elements (Gunderson and Holling 2009).

4. Examples from Alpine prehistory: settlement and resource mobilization, climate impact andinnovation, topographic resources and control, tertiary economy and added value

Alpine prehistory offers many settings to investigate system dynamics and to test models pertaining to cycles of development as outlined in the preceding sections. We will focus in

particular on aspects of resource mobilization (topographic, mineral, biotic, and human resources), climate impact such as during the "Löbben" oscillation, agricultural innovation, and strategies of economic growth, along with phases of stress and decline that might help explaining cyclical processes.

5. Conclusions

Adaptive cycles, such as observable in the early history of Alpine colonization and settlement, must be explained by taking into consideration both natural and human system dynamics. Elucidating the complex roles of technological innovations (Šmihula 2011), crisis and resilience promises exciting themes for future research.

Antony Brown and the TerrACE Team

*TerrACE Team: https://www.terrace.no/the-team*

**The sedaDNA of agricultural terraces: A new window on past agricultural history and biobiodiversity**

Whilst sedimentary ancient DNA (sedaDNA) has been extracted and analysed from lakes and caves it has rarely been used on open-air archaeological sites. The TerrACE project is the first use of sedaDNA on the cumulative soil-sediment packages preserved in agricultural terrace staircases. The results were far better than had been expected and did not follow the predicted latitudinal trends. This paper will present the plant and animal sedaDNA metabarcoding results from the project which analysed a transect of sites from Northern Norway to Eastern Crete. The terrace dating used charcoal 14C, HyPy 14C, and optically stimulated luminescence (OSL), and where possible the sedaDNA results were compared to plant phytoliths, pollen and charcoal analysis (anthracology). Particular attention will be given to the only site in the Alps at Villar d'Arene in eastern France which has a remarkable high-altitude terraced system and was still in use until recent times. The factors underlying the preservation and taphonomy of sedaDNA and its interpretation will be discussed along with the challenges that face its use in open-air archaeological sites.

Andreas Lang and the TerrACE Team

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**Timing the usage of agricultural terraces using luminescence dating: experiences from TerrACE**

Agricultural terraces are common features of cultivated hillsides across the world and have recently attracted increasing attention as archives of land-use practices. Such terraces originate from various soil translocation processes and throughout usage are subject of frequent reworking. Establishing chronologies for agricultural terraces usage is, thus,

notoriously difficult. Here, we report results from optically-stimulated luminescence dating of terrace sediments that

- originate from a wide range of locations across Europe stretching from the Polar circle to the Mediterranean;

- are derived from various host lithologies including igneous rocks, Triassic sedimentary rocks, Neogene marine deposits, and Pleistocene glacial and periglacial sediments;

- represent a range of cultivation styles including labor intensive manual techniques as well as mechanized tillage; and,

- cover a wide span of time periods from the Early Bronze Age through to modern times.

Reliable chronologies of optical ages, consistent internally and in agreement with independent age information, were established on silt-sized quartz extracts from loess derived terrace deposits and on sand-sized quartz grains derived mostly from sedimentary host rocks. OSL signals of quartz extracted from deposits with igneous and turbiditic host rocks are often not of sufficient quality for optical dating purposes.

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**Why stone-bench terraces in Catalonia are essential for soil and landscape conservation.**

Stone structures are ubiquitous in Catalonia, from the coastal line up to almost 2.000 m in the Pyrenees, preserving a rich heritage shaped by stone and environmental conditions. These constructions, from walls to huts, not only delineate landscapes but also sustain ecosystems. They define property and allow to cultivate slopes, with a historical peak in the 18th and 19th centuries driven by demand for olive oil, and later due to the wine post-phylloxera crisis or for cereal production in mountainous areas. While mechanization threatens these terraces, many persist, crucial for soil and water conservation and regulation. In Catalonia's Garrigues area, terraces facilitated olive cultivation amid economic growth, and have preserved organic-matter rich buried horizons formed during more humid periods. The soils on terraces in Vallbona de les Monges, where a large area in a mid-mountain fully-terraced landscape exists, are presented as example of the short-range spatial variability of their characteristics, and also as fundamental parts of the landscape in the XXI century, which should be preserved and valuated. In a context of climate change and water scarcity these terraced landscapes are an important alternative to maintain tree crop cultivation and landscape management , for instance, against forest fires and land abandonment.

Kevin Walsh and Florence Mocci, with the TerrACE Team and Charline Giguet-Covex

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**From travail to terrace: The evolution of a resilient but fragile landscape in French Alps**

The creation of a terraced landscape within mountains should not be considered merely as a logical or instinctive response to demographic increase and concomitant demands for food. It is also the consequence of emerging forms of environmental knowledge, in particular those that demonstrate an understanding of landscape susceptibility and, in particular, the risks associated with erosion. Therefore, any study of the development of terraced landscapes should review contingent historical, economic, social and environmental processes.

We will present a groundbreaking multi-scale analysis of the development of an Alpine terrace system at Villar-d'Arêne in the French Alps. While the most intensive period of terrace creation and associated agricultural activity can be dated to the High Medieval Period, there is evidence of earlier activity. We will contextualise this landscape via a brief review of our understanding of alpine lifeways through the ages. Then, focusing on Villar-d'Arêne we will present the results of a fully integrated archaeological and environmental study of the terraces. We will review the chronological evidence derived from carbon-14 dates and optically stimulated luminescence (OSL). The terrace system's environmental context will be presented via traditional geoarchaeological analyses (micromorphology, portable x-ray fluorescence (pXRF)), and anthracology, which provides evidence for the nature of the vegetation when the terraces were constructed. These landscape-specific analyses will be contextualised within a synthesis of a regional review of climatic, erosional and agricultural histories derived from studies of lake sediments (palynology, sedimentology, sedaDNA). In summary, this is a pioneering example of a fully integrated geoarchaeological/sedaDNA/palaeo-ecological study of an alpine terrace system, providing a comprehensive understanding of its evolution.

Markus Reindel, Christian Mader, Julia Meister, Johny Isla

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**Interdisciplinary investigations of agricultural terrace-settlement systems in the highlands of southern Peru**

The landscape of the tropical high mountains of the Andes poses enormous challenges for the adaptation of human societies, but also holds great potential for the development of agriculture. Sophisticated systems of terracing and water management were crucial to cope with the difficult topographical conditions and climatic fluctuations.

Our team investigated agricultural terrace-settlement systems in the highlands of southern Peru. Here we focus on two of these complexes located in the catchment area of the Palpa rivers on the western slopes of the Andes. Collanco is located at 1700 masl in the Palpa valley. Its terraces extend over 4 square kilometers and represent the oldest documented large-scale rain-fed irrigation system in the Andes. Cutamalla is located at 3300 masl. Large-scale excavations have revealed an extensive settlement with unique architectural patterns associated with agricultural terrace systems that extend over more than 220 hectares.

We applied a variety of archaeological and geoscientific methods, including archaeological and geomorphological surveys, archaeological excavations, drone surveys, mapping using satellite imagery and high-resolution digital elevation models, geographic information system applications, soil surveys, phytolith and starch analyses, numerical dating, and calculations of food supply capacity and labor requirements.

Our results show that the agricultural terrace-settlement systems of Collanco and Cutamalla were intensively used over a relatively short period (400 BCE–CE 100) under relatively humid climatic conditions. Maize was probably one of the main crops, alongside other economic activities such as camelid breeding, and provided the population of the coastal region of Paracas with resources.

Anirban Kumar Mandal, Franz Kerschhofer, Cindy De Jonge

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**Using chemical fossil in archaeology: Testing a method to reconstruct past soil fertility**

Glycerol dialkyl glycerol tetraethers (GDGTs) are a group of 20 molecules preserved in soils, peats and sediments. These cell membrane-spanning biomarker lipid molecules are well known for their high preservation potential over archeological and geological timescales. Branched GDGTs (brGDGTs) are produced by Acidobacteria in soils, while isoprenoid GDGTs (isoGDGTs) are produced by archaea. In soil, the composition of these membrane lipids varies with changes in temperature, soil pH, soil aridity, soil moisture, exchangeable calcium and exchangeable iron. Furthermore, the isoGDGT crenarchaeol can track the abundance of ammonia oxidizing archaea in soils. Many of these soil chemistry parameters are expected to vary with land use changes on a Holocene timescale, for instance in response to fertilization practices such as liming or the application of animal manure to fields.

Given the promising preliminary results of these molecular tools, we seek new collaborations to test whether the proposed GDGT ratios can track past changes in soil chemistry parameters. For instance, we can target paleosoils formed by human land use changes. Through this, we aim to reconstruct past soil chemistry and environments, contributing to a deeper understanding of historical land use changes and their long-term impact on environmental dynamics.