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Researching Change – Understanding Change – Facing Change. 3500 years of human-environment relations in the Hallstatt/Dachstein region

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Summary

Coring lake Hallstatt with the Hipercorig coring device. Image credit: Reschreiter/NHM Wien

The Hallstatt High Valley represents one of Europe's oldest cultural and industrial landscapes. For millennia this remote alpine valley was the demographic and economic centre of a wide region. In this landscape the evidence for large-scale underground salt mining runs from the present day back to the Bronze Age. The oldest secure evidence for such mining dates to the 14th century BC. However, various indicators point towards a much older tradition of salt production, reaching far into Neolithic times. The extraordinary preservation conditions in the salt mines

and the variety of archaeological, historical and environmental sources allow for unique insights into prehistoric technology, raw material management, working processes and human-environment relations.

The Hallstatt/Dachstein region represents an alpine environment, where the evolution of human-environment relations can be tracked over a long time period. Recent research has focused on the impact of natural extreme events on these highly sophisticated socio-economic systems. Through this research it was possible to document the high degree of resilience of Bronze Age and Iron Age communities in the face of devastating extreme natural events such as mass movements and substantial climate change.

In this article we will address the questions of 'understanding past adaptation strategies and facing future challenges' and 'the role of archaeologists in addressing climate change', based on our longstanding research and outreach activities in the Hallstatt region.

1. Introduction

Climate Change and Archaeology, the 22nd symposium of the European Archaeological Council, addressed one growing challenge to humanity while another one was already in full swing. The Covid-19 pandemic, which forced us to take our discussions into the virtual space, is of course in the first instance a health problem and has quickly become a social, financial and infrastructural challenge. But it is also a stark reminder of humanity's close interrelationship with the earth system and of the impact that 'natural' processes can have on us socio-biological beings. As we experience the forces of 'nature' to an extent that many of us might have considered a 'problem of the past', we are called upon to turn our attention to another aspect of this interrelationship. Climate change will transform the matrix of our lives in the very near future; at present we are all experiencing the dynamics of exponential growth.

So we ask, how can we as archaeologists *support society in adapting to the changing climate and a low carbon future* (EAC 2021, 1). As archaeologists we bring a substantial number of skills to the table such as a diachronic perspective, process understanding, interdisciplinarity and systems thinking. (This is of course something that we share with a number of other disciplines, and we need to work together to address these challenges.) We, together with our colleagues from the earth and bio sciences, deal in the long-term observation of socio-ecological systems, the impact of boundary breaches, transformations and processes of adaptation to environmental and social change.

In this article we present a selection of the research and outreach activity carried out in the UNESCO World Heritage area Hallstatt-Dachstein/Salzkammergut (Austria) to discuss how interdisciplinary research with a strong archaeological component can contribute to the understanding of socio-ecological systems and how this might help to address future challenges and also what *role archaeologists can play in communicating and engaging with climate change* (EAC 2021, 1).

2. The UNESCO World Heritage Area Hallstatt-Dachstein/Salzkammergut: a core area to study change and adaptation

At first glance, one might miss that the Hallstatt-Dachstein/Salzkammergut area is a World Cultural Heritage Site, but this landscape has been shaped by its long industrial history, the extraction of rock salt, stretching from the Stone Age until today. This exceptional landscape, located in the Eastern Alps, was listed as a UNESCO World Heritage Site in 1996.

Figure 1: The UNESCO World Heritage Area Hallstatt-Dachstein Salzkammergut seen from Graseck. Image credit: D. Brandner

Figure 2: Explore the UNESCO World Heritage Area Hallstatt-Dachstein Salzkammergut in 360°. Image credit: D. Brandner/NHM Vienna

Large-scale underground salt mining in the Hallstatt salt mountain is documented from the 14th century BC to the present day with short interruptions (Festi *et al*. 2021). In addition, remains of a Bronze Age meat-curing industry and the cemetery of the Iron Age miners are located in this narrow valley.

Figure 3: The view from the Rudolfsturm tower covers 7000 years of industry. Image credit: D. Brandner

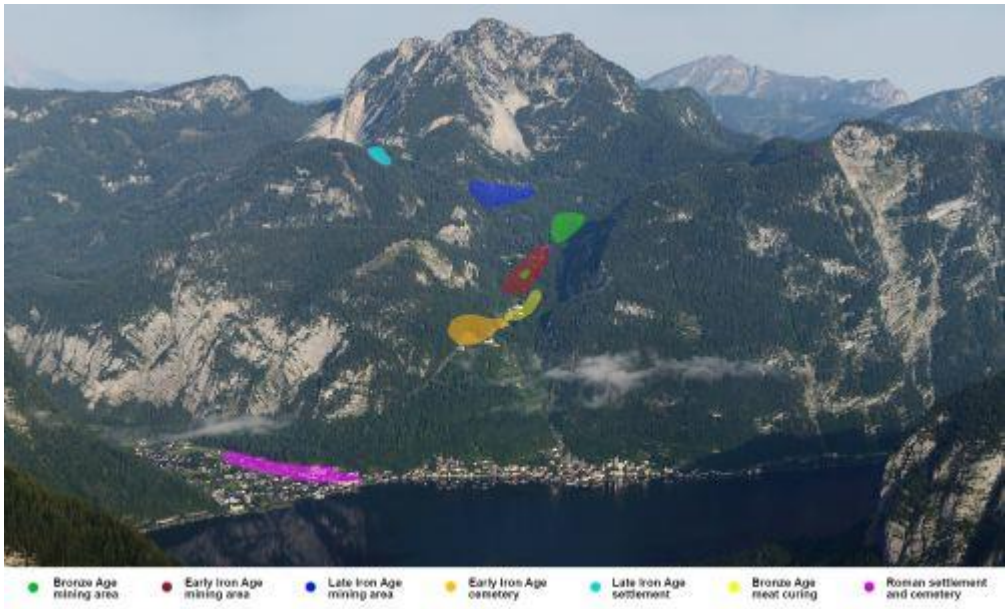

Figure 4: For millennia this remote alpine area was the demographic and economic centre of a wide region. Image credit: D. Brandner

The depth and size of the prehistoric mine workings as well as the sheer number of prehistoric tools and working materials left in the mines document the substantial near-industrial scale of salt mining in Hallstatt as early as the Bronze Age (Kowarik *et al*. 2019).

[Embedded video]

Figure 5: Schematic presentation of the Bronze Age and Iron Age mine workings, D. Brandner, H. Reschreiter/NHM Vienna. (View on Vimeo)

[Embedded model]

Figure 6: Hallstatt prehistoric salt mine. Image credit: D. Brandner/NHM Vienna. View on Sketchfab

The extraordinary preservation conditions inside the salt mines enable insights into prehistoric life. Dense layers of production waste reaching a thickness of several metres were excavated in the Bronze Age and Iron Age mine workings in the Hallstatt salt mountain, uncovering thousands of wooden tools and construction elements, implements made from fur, rawhide, hundreds of woollen textile fragments, and grass and bast ropes. Just recently the consumption of blue cheese and beer was documented through DNA analysis of excrement from Iron Age miners (Maixner *et al*. 2021).

Figure 7: Archaeological finds from the salt mines in 3-D (click to open): a) Iron Age pick, b) Bronze Age carrying sack, c) Bronze Age bucket; to explore more finds from Hallstatt in 3-D see https://skfb.ly/onSNI. Image credit: D. Brandner/NHM Vienna

3. Studying Change and Adaptation

This landscape provides ideal conditions to study the impact of environmental change and human-environment relations for several reasons:

1. owing to the long-standing salt mining tradition (14th century BC to the present) and the early advent of tourism (18th century AD) the area represents a long-term focus of intense human activity and must be considered as a heavily human-influenced environment,
2. socio-economic activity is well documented through archaeological research and historical documents,
3. different types of sedimentary archives (lake sediments, bogs) from different altitudinal belts exist, and
4. extreme events repeatedly disrupted and respectively altered the economic activities in the region by destroying the prehistoric Hallstatt salt mines.

Until recently human-environment relations in this area were not well understood, but this has begun to change through a targeted research programme. In our research we focus on understanding the evolution of this highly complex socio-ecological system through the integrated investigation of cultural and natural archives. We are also dedicating a substantial amount of our efforts into establishing a lasting inter- and transdisciplinary network.

3.1 FACEALPS – Facing change in the Alps. *3500 years of human-environment interrelation in the UNESCO World Heritage Region of Hallstatt-Dachstein/Salzkammergut*

This project is part of the international Earth System Science research framework, which in Austria is curated by the Austrian Academy of Sciences. The project itself was hosted at the Natural History Museum Vienna in cooperation with inter- and transdisciplinary partners.

Figure 8: Explore the Natural History Museum Vienna and its labs. Image credit: D. Brandner/NHM Vienna

Our research goal in this project was to investigate the interrelation between environmental change and human land use dynamics in the late Holocene. The principal objectives were to investigate how certain types of extreme events influenced the socio-ecological systems and to trace the development of human-environment relations in the UNESCO World Heritage region Hallstatt-Dachstein from the beginnings of underground salt mining in the Hallstatt High Valley dating from the 14th century BC until the present day.

A well-resolved palaeoenvironmental record was established based on the palynological analysis of a peat core from the Siegmoos bog (Festi *et al*. 2021; Knierzinger *et al*. 2021) and lake sediments (Drescher-Schneider *et al*. in prep). It could be demonstrated that the communities living in the landscape were well aware of system boundaries, managed raw material resources, such as forests, accordingly and had substantial resilience in face of natural hazards over the last 3000 years. Bronze Age forest management practices were reconstructed (Grabner *et al*. 2021). An inventory of late Holocene geologic and climatic extreme events was set up based on bathymetric mapping and seismic surveys of the lake basin (Strasser *et al*. 2020), analysis of long and short sediment cores (Lauterbach *et al*. in review; Strasser *et al*. 2020) and geoelectrical investigations of landslides in the High Valley as well as an analysis of historical written records (Kowarik *et al*. in prep). A new picture of environmental dynamics and human response during prehistory in the research area has emerged, indicating a higher frequency of extreme events than hitherto expected and substantial resilience of human communities in the face of these events. Finally, we were able to establish a research network integrating inter- and transdisciplinary partners from a wide range of institutions and individual backgrounds.

3.2 Hipercorig. *Accessing a deep time window into the past of the World Heritage area Hallstatt-Dachstein/Salzkammergut*

The palaeoenvironmental record established through Facealps reconstructs the last 6000 years in mid-level time resolution through the Siegmoos bog (Festi *et al*. 2021) and the last 2300 years in high resolution through the sediment cores taken from lake Hallstatt in 2012 and 2016 (Lauterbach *et al*. 2017; Lauterbach *et al*. in prep). A sedimentary sequence covering the early Holocene and late Glacial periods, and thus reaching back over 11,700 years in high resolution, was urgently needed. But to achieve this it was necessary to overcome the coring limit of ~16m (stratigraphic age ~2,300 cal BP) by deploying the newly developed hydraulic coring system Hipercorig (Harms *et al*. 2020). To do so the Hipercorig coring consortium was set up in 2020 under the lead of Michael Strasser (University of Innsbruck) with partners from the Natural History Museum Vienna, the University of Bern and the GeoForschungsZentrum Potsdam. The project was mainly funded by the Austrian Academy of Sciences (ÖAW), the University of Innsbruck and the Verein der Freunde des NHMW (project website).

Figure 9: Coring lake Hallstatt with the Hipercorig coring device. Image credit: Reschreiter/NHM Wien

[Embedded video]

Figure 9b: Time lapse video of the six-week coring campaign, Ortler/Rittmannsperger/Kowarik/Strasser/Reschreiter/NHM Wien & UIBK

Documentary: Text captions in German.

A six-week coring campaign in spring 2021 resulted in the successful retrieval of two nearly continuous sedimentary sequences, 41m and 51m in length, reaching a new depth record for scientific coring in an intramountainous lake. At present the cores undergo 3D-structural (X-ray computed) tomography, sedimentological, physical and element chemical core logging and scanning analysis at the Austrian Core Facility for scientific core analyses, University of Innsbruck, and organic macro remains are being measured by radiocarbon analyses as input for high-resolution chronological modelling within the ÖAW-IGCP project S4LIDE-Hallstatt project.

Several project proposals are underway for multiproxy based research covering themes from Holocene activity in alpine landscapes, long-term investigation of human-environment relations and human response to natural hazards as well as research on past climate changes and their effects on human land use in mountain regions. This lays the foundation for new and highly innovative research on human-environment interrelations, human response to natural hazards as well as past environmental and climatic conditions in one of the World's oldest cultural and industrial landscapes.

Figure 10: Explore Austrian Core Scanning facility at the University of Innsbruck in 360°. Image credit: D. Brandner/NHM Vienna and Univ. of Innsbruck

3.3 Groundcheck: Saltscape Hallstatt. *Human-environment interaction and palaeoclimate at high altitude in the Hallstatt-Dachstein saltscape*

In the Saltscape Hallstatt project we investigate the evolution of the socio-ecological system on the high alpine karstic plateau of the Dachstein mountain range. This landscape has seen steady human activity at least since the Bronze Age, when it was used as pasturing ground, ritual landscape and communication corridor (Mandl 2015; Kowarik 2019). We are particularly interested in addressing the question of the vulnerability and resilience of human societies in this challenging landscape and to observe in detail the reactions of the high alpine ecosystem to climate change in a diachronic long-term perspective (https://www.dainst.blog/crossing-borders/2021/10/29/zu-besuch-in-der-salzlandschaft-hallstatt/).

Figure 11: Explore the karstic plateau of the Dachstein massive in 360°. Image credit: D. Brandner

The project is part of the research programme Groundcheck, which was designed to address two challenges: i) investigate past climate and societal dynamics, and ii) support research on heritage in view of climate change. It is one of nine research clusters of the German Archaeological Institute and funded through of the Ministry of Foreign Affairs of the German Government.

In our first field campaign we cored the alpine lake Grafenbergsee, which is located at 1600m asl and is in close proximity to Bronze Age pasture sites. A surface drill core of 1.5m and two sediment sequences of 5m and 6m length were retrieved and are currently under investigation at the Institute of Geology (University of Innsbruck).

Figure 12: The coring platform is transported to Grafenbergsee via helicopter. Image credit: D. Brandner/NHM Vienna

[Embedded video]

Figure 13: Drone flight over coring platform at Grafenbergsee. Image credit: R. Scholz/RGK. (View on Vimeo)

Further multiproxy analysis will target the human impact of landcover and vegetation composition as well as societal and ecosystemic response to climate change. The overall objective of these research activities is to build a highly resolved multiproxy record integrating a wide range of cultural and natural archives. This forms the basis for the modelling of landcover change as well as human-/animal-environment interactions.

The number of field campaigns and the stakeholders involved in enabling these activities have strongly contributed to the growth of our transdisciplinary network and the integration of citizen science activity into our research programme.

4. A Core Area to Communicate and Engage with Climate Change

Not only is the saltscape of Hallstatt well suited for the study of the impact of climate change on socio-ecological systems, it is also a good place to engage with individual people and institutions on this topic.

The Natural History Museum Vienna has a long-standing presence in the region. It has conducted archaeological excavations in the Hallstatt High Valley since the 1960s in cooperation with the salt mining company, Salinen Austria AG, and its tourism branch (Salzwelten GmbH), so there is a well-developed local network. In addition, the UNESCO area Hallstatt-Dachstein is a tourist hotspot. In addition, the Hallstatt High Valley represents a substantial visitor attraction with guided tours into the salt mines, which are managed by Salzwelten GmbH. Outreach activities are organised in close cooperation between the Natural History Museum Vienna and the Salzwelten GmbH. This offers a twofold opportunity to engage in the long term with the local population and to communicate with a wide national and international audience. With infotainment we can reach more than 100,000 visitors each year with the history of salt production in Hallstatt.

Figure 14: The final point of the underground tour in the Salzwelten is the Bronze Age cinema. Image credit: Bronzezeitkino, Scenomedia

Figure 15a-b: Outreach activities span from local science fairs to exhibitions in the Natural History Museum to virtual projects. Image credit: H. Pernkopf/Salzwelten

One of the substantial challenges is the invisibility of this World Heritage hidden under the earth and in the salt mountain. Therefore, virtual and augmented reality are a focus of our work, as well as experimental archaeology (Reschreiter *et al*. 2019).

Through these activities we aim to convey on a general level the processual and historical nature of human-environment relations, systems complexity, and the way scientific knowledge is generated. More specifically, we aim to communicate and engage on these questions:

- How have humans impacted on the earth system throughout the millennia?
- How have changes in the Earth system affected human societies?
- How are we connected, entangled with our environment and the Earth system, how has this relationship evolved and how will it go on evolving?

A selection of recent and future projects is described below.

4.1 VirtualArch – generation of scientific knowledge

The Interreg Project VirtualArch is driving the visualisation of this underground World Heritage Site. Viewers can virtually walk with Bronze Age miners through the enormous shafts and mine salt with them in the mining works using a bronze pick.

Figure 16: The goal of Hallstatt VR is, however, not 'only' to present a good optical impression of the prehistoric mines, but to demonstrate the large amount of data used to build the model of the prehistoric mine and where the individual pieces of information come from. Image credit: C. Fasching/NHM Vienna

One focus of the coming work will be to visualise how research is done on the finds from the mines, i.e. which analyses are performed, which techniques are used for the analyses and which labs are commissioned to perform them. It will soon be possible with the aid of VR glasses to start out in the Hallstatt mine, teleport to the dendrochronology lab analysing the wooden tools or to the core scanning lab analysing the sediment cores. A basic lab tour via 360° panoramas is already available.

4.2 Sustainability Parcour

To actively engage people visiting this World Heritage site, in cooperation with the Salzwelten GmbH we developed a sustainability parcour through the High Valley. This themed adventure trail is aimed at families with children. At various points on the trail visitors have to solve riddles and challenges revolving around raw materials and resource consumption. One of the main messages is the relation between energy need and resource consumption, as well as historical and processual thinking.

4.3 Hallstatt Game(s) – learning and engaging through gaming

To contribute to the creation of transformative knowledge and to promote the establishment of participatory structures we plan to develop a serious game based on the history of this landscape, one that revolves around sustainability themes such as resource consumption, human-environment relations and that strengthens system and complexity thinking. This will also allow us to target new audiences.

5. Conclusions

Resilient long-term socio-ecological systems are characterised by a thorough understanding and respect of system boundaries and an efficient social compliance management preventing overshoot (Ostrom 2015). Reconstructing the evolution of these systems and observing their dynamics using computer modelling provides the basis for a thorough and specific understanding of these systems. This understanding is urgently needed to enable a successful translation of past practices into socially acceptable practices for the societies of the 21st century. These objectives can only be achieved through inter- and transdisciplinary research frameworks. Archaeology alongside Earth and Bio Sciences as well as Complexity Research can contribute to these objectives.

Going from research to public engagement and further to effective translation of research results into societal practice requires substantial transdisciplinary expertise. Archaeologists can play an important role in forming these partnerships, as we usually have good networks with local institutions and individuals. Field campaigns where a large number of stakeholders have to be contacted and informed about research objectives and methods can serve as focal points for community engagement and community building. Archaeology in general has the potential to teach systems and complexity perspectives as well as to educate about the value of raw material and resource consumption. Again, this can only be done well in cooperation with other fields of expertise. Finally, networking with other initiatives is essential to build critical mass and bring together the necessary expertise.

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