From lakeshore to hilltop. Investigating Copper Age landuse in the Attersee-Mondsee region

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Introduction

The investigations presented in this paper are part of a trinational research effort tracing human-environment relations in the area of the northern Alpine lakes throughout the Holocene. The project 'Beyond Lake Villages' (BeLaVi) brings together research groups from Switzerland, Germany, and Austria within a transdisciplinary research framework. In three different research areas closely integrated archaeological and palaeoecological studies were conducted to investigate human-environment relations with special attention to the time period of the 4th mil. BC.

The Austrian part of the BeLaVi project focuses on the core area of the Mondsee group (Figure 1). Of Austria's nearly 30 waterlogged sites 22 are attributed to this cultural entity. These sites lie scattered around the lakes Attersee and Mondsee at the periphery of the Northern Limestone Alps. Together with the cultural entities of Cortaillod and Pfyn, the Mondsee group counts among the earliest copper-using horizon north of the Alps (Frank and Pernicka 2012; Ruttkay et al. 2004). The rich material culture of these lacustrine sites indicates a complex socioeconomic structure and farreaching transalpine contacts (Ruttkay et al. 2013, 2004). Within

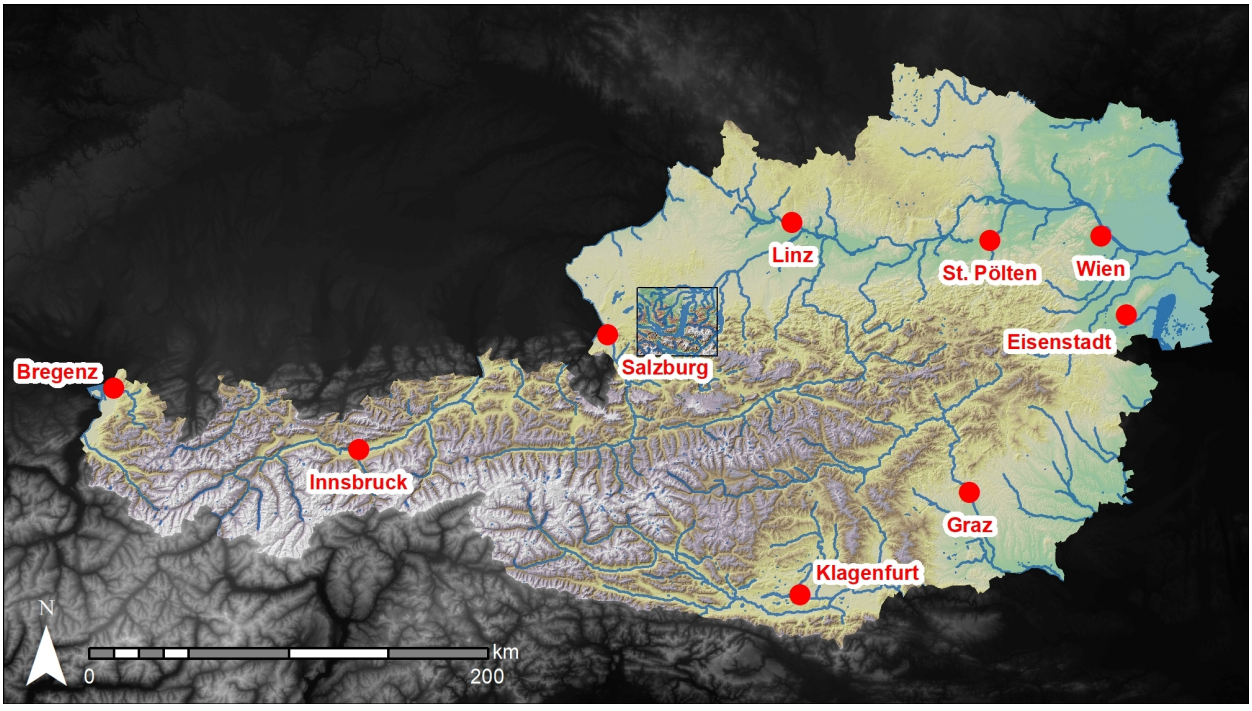

Figure 1: The resarch area of the BeLaVi Austria project is located on the northern border of the Eastern Alps in the historical Salzkammergut region. Data source: Land Oberösterreich, CGIAR-CSI, Geofabrik GmbH and Open Street Map contributors. Map author: Julia Klammer.

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the BeLaVi Austria project we aim at developing a more detailed picture through the investigation of landuse and human-environment relation. Our approach targets different spatial scales and perspectives by combining landscape archaeology research such as spatial analysis, LiDaR, and field survey with archaeological excavations and palaeoecological research focused on the establishment of highly resolved palaeoenvironmental records. In the present paper we discuss first results of our landscape archaeology work by adressing visual patterns, landscape characterization and site location choice.

State of research

The Mondsee Group

The geographical distribution of the Mondsee group is rather limited. Sites undisputedly attributed to this group are located in the northern Alpine foreland of Upper Austria south of the Danube between the Salzach valley to the East and the Enns valley to west. The core area of the Mondsee group lies in the southern part of this region and is constituted by 22 lacustrine sites on the shores of lakes Attersee and Mondsee. Sites with the distinctive Mondsee ceramic are distributed over a wider area from eastern Bavaria to Lower Austria to the southern alpine foreland in Styria (Buchvaldek et al. 2007, map 14a-15a; Ruttkay 1981, 1998; Maurer 2014, esp. Figure 1).[1] There are indications that the geographic distribution within the Mondsee group area might contain a chronological element, with sites attributed to an older phase (Mondsee 1) mainly known from dryland, whilst many of the younger phase sites (Mondsee 2) are located in the shore area of lakes Attersee and Mondsee (cf. Maurer 2014).

1: At present no burial sites are known.

Looking at site location choice of Mondsee settlements a certain variability is detectable, ranging from lake shores, to river confluences to elevated positions on hilltops (with larger settlement areas), and small cliffs. Jakob Maurer has recently drawn attention to the eastern periphery of the Mondsee area, reevaluating a small group of sites located 20 to 25 km east of the Enns valley (Maurer 2014, pp. 147–52). One of the most striking features of this group of small-scale settlements is a marked preference for small and steep rock cliffs offering only very limited settlement space (40 m^2 to 500 m^2). Some sites seem to have been settled during prehistory only in the 4th millennium, such as the small cliffs, others such as the hilltop settlement site of Ansfelden just south of the Danube, were settled throughout prehistory (Trebsche 2008). As to the lacustrine sites, in the course of the underwater excavation programme conducted by the Kuratorium Pfahlbauten and the Federal State Museum of Upper Austria since 2015 evidence for multiperiod settlement activity on the lake shore is emerging (Pohl 2015, 2016).

The typology of the Mondsee group was initially divided into three phases Mondsee 1-3 (Ruttkay 1981). At present, phases Mondsee 1 and 2 are considered to represent the actual Younger Neolithic Mondsee group, whereas Mondsee 3 could represent a local expression of Late Neolithic Cham (Ruttkay 1998; Ruttkay et al. 2004). Elisabeth Ruttkay pointed out strong correlations between Mondsee 1 and the young neolithic groups of Pfyn and Altheim and typological correlations between Mondsee 2 and

early Baden (Boléraz phase) (Ruttkay et al. 2004, pp. 58–59, 2013, p. 247). In absolute terms the Mondsee group is currently dated from 3800–2900 BC, with Mondsee 1 and 2 falling between 3800 to 3100 and Mondsee 3 perhaps between 3100–2900 (Dworsky and Reitmaier 2004; Frank and Pernicka 2012; Krenn-Leeb 2006; Ruttkay et al. 2004, pp. 58–59). But due to the lack of closed finds the chronological framework remains coarse grained. At present the end of Mondsee 2 can only be dated to a time span between the 35th and 31st century BC. The chronological framework of the Mondsee group is based on unstratified materials from the lacustrine sites. In its foundations it relies upon the typochronological phasing of selected materials from the various lacustrine sites proposed by Elisabeth Ruttkay in 1981 (Ruttkay 1981). The absolute chronology is constituted of radiocarbon measurements (cf. Krenn-Leeb 2006; Ruttkay et al. 2004, 2013). The bulk of these samples were taken from wooden piles in the course of surveying campaigns during the 1970s and 1980s and the early 2000s (Dworsky and Reitmaier 2004; Offenberger 1981, 1986). Neither the archaeological materials nor the samples for radiocarbon measurements come from closed contexts. Until very recently no closed find contexts of the 4th millenium BC were known from the core area of the Mondsee group. Current research activities aim at developing a reliable and well resolved chronological framework.

The discussion of the economic and social structure of the Mondsee group is mainly based on the lacustrine sites. The idea that the communities living on the shores of lake Attersee and Mondsee were a central part of a transregional network and played an important role in the material flows of the wider region, especially copper, was proposed early on (Franz 1928). This model was based on topographic (hydrological network), geographic (proximity to copper districts in the Salzach Valley), and archaeological considerations (number of copper objects). Later on, this idea was heavily criticized also on the basis of topo-geographic considerations (Willvonseder 1963, pp. 8–12, 299–307). Willvonseder emphasized the low regional and transregional connectivity of the area and developed a model of mainly agrarian based farming communities. As in the following years underwater surveys increased the number of known sites and expanded the find inventory, it became ever more obvious that copper must have played an important role in the economy of the lacustrine communities (Obereder et al. 1993). In fact the Attersee-Mondsee region represents one of the densest find regions for 4th millenium copper objects and casting crucibles in Europe (Frank and Pernicka 2012; Obereder et al. 1993; Ruttkay et al. 2013, 2004). Currently about 70 copper objects and more than 160 fragments of casting crucibles are known (Obereder et al. 1993). Based on these observations Ruttkay et al. suggested a reevaluation of the economic and social structure of communities living on the lake shores (Ruttkay et al. 2004).

> 'The inhabitants of the pile dwelling settlements are generally referred to as "pile farmers". At Mondsee, this is not entirely accurate. The most famous elements of the archaeological record are the metal finds: in particular, the evidence of local copper processing.' (Ruttkay et al. 2004, p. 57).

The copper objects found in the lacustrine sites of the Attersee-Mondsee region are caracterized by 'a high arsenic (0,5 per cent to 5 per cent) content while antimony, silver, and nickel are only present in very low concentrations' (Frank and Pernicka 2012, p. 124). Objects with this composi-

tion have a wide distribution over Europe from the Carpathian region to Scandinavia and the Rhône valley (Gleirscher 2007, pp. 105–106; Krause 2003, pp. 147–160), but show a special density in the Attersee-Mondsee region as well as in Eastern Switzerland (Frank and Pernicka 2012; Matuschik 1997; Obereder et al. 1993; Ottaway 1982). The origin of this copper is yet unknown, but Caroline Frank and Ernst Pernicka have recently excluded the possibility of an eastern alpine provenance and pointed towards southeastern Europe as a possible area of origin (Frank and Pernicka 2012). The role of the Mondsee group and the Attersee-Mondsee region within this network is unclear for the moment. Apart from the copper objects, casting spills, and crucibles other material categories such as ceramics, silex, and archaeobiological materials suggest widespread contacts within and across the alpine zone, reaching as far as the middle Danube region (Maurer 2014, pp. 155–166; Ruttkay et al. 2004, 2013).

The research area: environmental characteristics and research history

The prealpine lakes Attersee and Mondsee are located in the alpine foreland on the northern border of the Eastern Alps (Figure 1, Figure 2). The area is part of the historical region *Salzkammergut* and connects two major natural regions, the alpine foreland to the north and the Limestone Alps to the South. The research area stretches around lakes Attersee and Mondsee. It can be subdivided into three zones running from North to South. The northernmost part is dominated by the hilly landforms of the alpine foreland and belongs geologically to the Molasse zone. End moraines and deeply incised river valleys (e.g. Vöckla, Dürre Ager, Ager) shape the landscape, which reaches maximal heights of 500 m. The southern border of this area runs just North of lake Attersee. The adjacent section belongs to the Flysch zone and makes up the largest part of the research area. The landscape is shaped by the large perialpine lakes (Irsee, Fuschlsee, Irrsee, Mondsee, Attersee etc.), end moraines, and the Flysch mountains. The height of 1000 m is only rarely surpassed. In the southernmost part of the research area the steep rock walls of the lime stone alps dominate.

About 70 lakes are known from the wider Salzkammergut region. Within the research area lie three of the largest (Attersee, Mondsee, Wolfgangsee) and roughly ten mid-size to small lakes (e.g. Irsee, Fuschlsee, Langbathseen). Lacustrine sites are only known from lakes Attersee and Mondsee. These form the chain of lakes Irrsee-Mondsee-Attersee strechting roughly from northwest to southeast to east. Irsee, Mondsee, and Attersee represent typical glacial lakes. Both lake Mondsee (16,6 km^2, max. depth 68 m) and lake Attersee (46,2 km^2, max. depth 169 m) are characterized by a gradual change from perialpine landforms in the northern part to alpine landforms in the South. Sheer limestone rock walls rise on the southeastern shore of Lake Mondsee and encompass the southern end of lake Attersee. On both lakes the areas directly adjacent to the lake shore are predominantly formed by steep slopes belonging either to the ridges of the limestone alps or in the northern part to Flysch mountains. Gently sloped shore areas and flat-open hinterlands are limited to the northwestern / northern part of lake Attersee and on lake Mondsee to its western end and a small stretch on the northern shore. Lake Irrsee (3,55 km^2, max. depth 32 m), the smallest in the lake chain, is located

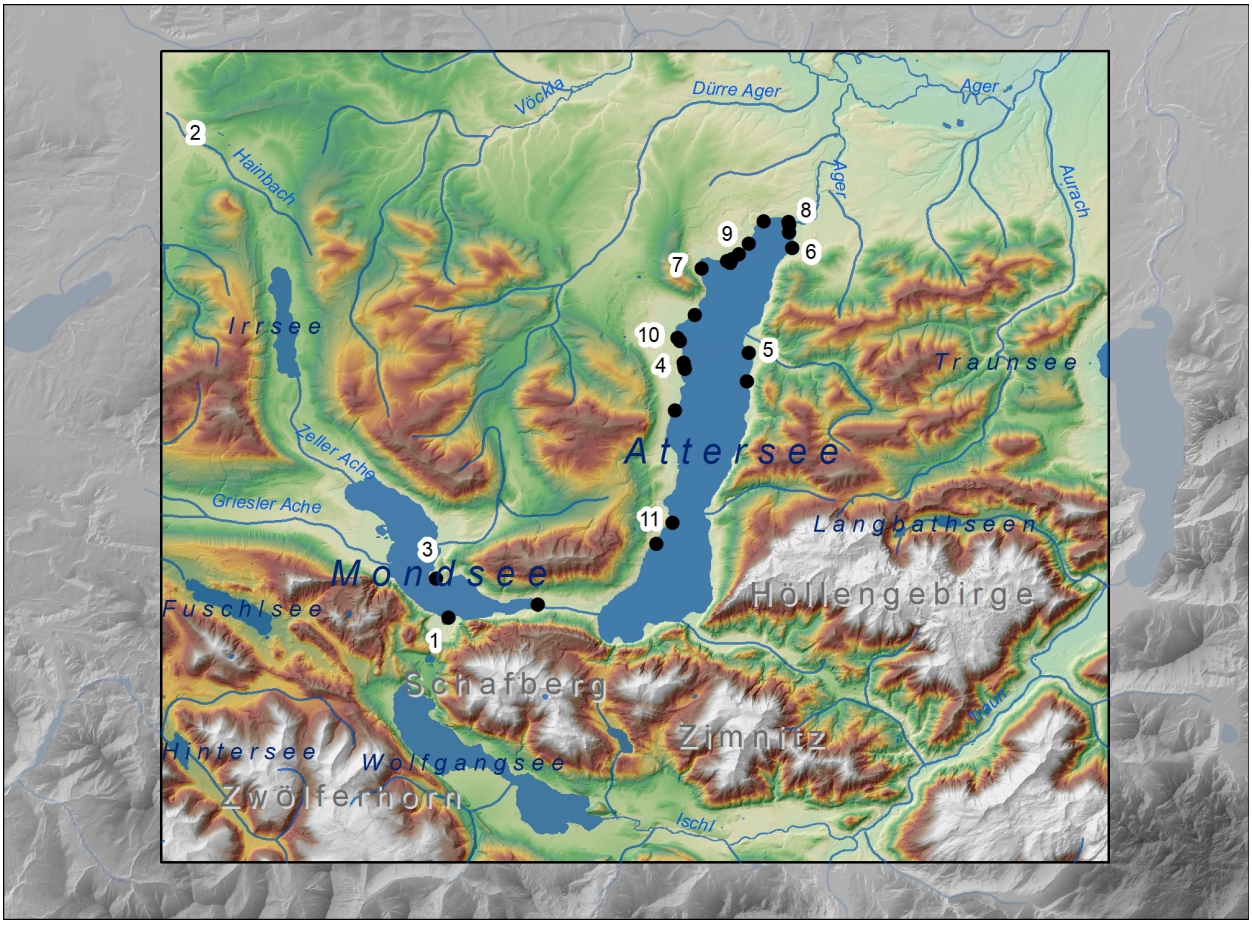

Figure 2: Research Area with all known lacustrine sites sites. Data source: Land Oberösterreich, CGIAR-CSI, Geofabrik GmbH and Open Street Map contributors. Map author: Julia Klammer.

entirely in the perialpine foreland. Amongst the area's numerous watercourses the Traun river and the Ager river are the most important. The Traun and its tributaries drain the entire Salzkammergut region and link it to the Danube valley. The Traun river only crosses the research area in its easternmost corner. The Ager river, one of its most important tributaries, is the dominant drainage system here (catchment area 1260 km^2). It is the sole effluent of lake Attersee. From lake Attersee the Ager runs Northeast into the Molasse zone and forms together with the Vöckla river the eastward running Vöckla-Ager valley in the northernmost part of the research area. About 30 km northeast of lake Attersee the Ager flows into the Traun river which in turn flows into the Danube. Whereas lake Attersee drains to the north into the prealpine foreland through the Ager river the other two lakes of the lake chain, Mondsee and Irrsee, drain to the South. Lake Irrsee's sole effluent, the Zeller Ache, connects Irrsee to Mondsee and lake Mondsee's only effluent, the Seeache, runs into lake Attersee. Thus through lake Attersee the Ager also drains lakes Mondsee and Irrsee. The Ager's most important tributaries Vöckla, Dürre Ager, and Aurach are typical Flysch zone rivers with strong seasonal changes in water volume.

For more than 130 years the research activity within the area has been focused on the lacustrine sites. The sites on the shores of lakes Attersee and

Mondsee make up the bulk of the 4th mil. site inventory in the research area (Figure 2). Of the 23 sites dated to the 4th mil. 22 are lacustrine sites. The first discoveries of lacustrine sites on Attersee and Mondsee were made in the 1870s (Ruttkay 1998). This initiated a period of intense interest lasting well into the first of half of 20th cent. A considerable number of sites were discovered. Objects were dredged up in large quantities by means of shovels, nets, and poles. Especially the site of See/Mondsee yielded a great number of finds. Comprehensive publications of the rich find materials first appeared for Mondsee in 1927 (Franz and Weninger 1927) and for Attersee in the 1960s (Willvonseder 1963). In 1969 the Federal Office for Monument Protection initiated an underwater survey programme (1969 to 1986). The project, headed by Johann Offenberger, involved surveying the lake shore for new sites, documenting and inventorizing the known sites, and retrieving characteristic samples of material culture as well as sampling for dendrochronological analysis and radiocarbon dating (Czech 1989; Offenberger 1986). During this time several research initiatives were launched (Offenberger 1986). These included a more detailed investigation of the site of See am Mondsee by means of a prospection trench. Here a considerable number of archaeological and bioarchaeological materials were retrieved. Palynological, sedimentological, and macro remain analysis were conducted on several on-site cores from the settlement sites of Weyregg I/Attersee, Aufham/Attersee, and See/Mondsee (Chondrogianni et al. 1986; Schmidt 1982, 1986). Especially the investigations on the See cores gave first insights into subsistence strategies and landuse (Schmidt 1986). After 1986 all survey and excavation activity came to a halt.

Between 1989 and 1995 an interdisciplinary research project headed by Elisabeth Ruttkay focused on the analysis of the find materials that had been retrieved from the Upper Austrian and Carinthian underwater sites until 1986 (Ruttkay 1995). For Upper Austria a study of the archaeozoological material from Lake Mondsee was published (Pucher and Engl 1997), as well as a catalogue of the ceramics from these sites (Lochner 1997), and a number of preliminary reports on various object categories appeared (Antl-Weiser and Holzer 1995; Antl-Weiser 2006; Obereder et al. 1993). In the early 2000s a renewed underwater survey programme aimed at inventorizing the known lakeshore sites and assessing the state of preservation (Dworsky and Reitmaier 2004).

One of the most important impulses for research on Austria's lacustrine sites came in 2011 with the conferral of UNESCO World Heritage status for 111 lacustrine sites around the Alps including five sites in Austria.[2] The conferral of World Heritage status led to the creation of institutional structures for management and monitoring of the World Heritage sites (Kuratorium Pfahlbauten) and engendered a new phase of research activity. In 2014 the University of Vienna started an excavation programme in the hinter-land of the lakes (Herzog et al. 2014, 2015). And one year later, in 2015, the Kuratorium Pfahlbauten and the Federal State Museum of Upper Austria initiated an underwater excavation programme, the Zeitensprung project, targeting the lacustrine sites in Lakes Attersee and Mondsee (Dworsky and Novak 2012; Pohl 2015, 2016). Both projects address one of the most pressing issues, namely the lack of large-scale excavations and subsequently the lack of well controlled and highly resolved chronostratigraphies. A new and more detailed picture is beginning to emerge. One of the most important findings of the dryland campaigns

2: Carinthia: Keutschacher See, Upper Austria: Attersee: Abtsdorf I u. III, Litzlberg Süd, Seewalchen; Mondsee: See am Mondsee.

was the discovery of a hilltop settlement dating to the 4th and early 3rd millennium BC just north of lake Attersee at Lenzing. For the first time in Austria, we have knowledge of a hinterland settlement contemporaneous with the lakeshore sites. The underwater excavations have uncovered likely evidence for settlement activity in the lacustrine zone already in the 5th millenium BC, indications for human activity in 6th mil. BC and are beginning to shed light on the settlement dynamics of the 4th mil. BC (Pohl 2015, 2016). With the start of the Beyond Lake Villages project the excavations were expanded through closely integrated landscape archaeology analysis and palaeoecological research.

Tracing visual patterns, landscape connectivity and site location choice

Our approach is based on four work packages: i) landscape classification, ii) site catchment analysis, iii) LiDaR prospection, and field survey, iv) diachronic analysis. This allows us to address different spatial scales from site level to landscape level. Here we present preliminary results of our landscape work with a focus on visual patterns, connectivity of the landscape and site location choice.

Visibility patterns on landscape level

Shoreline and waterbody must be considered as landscape elements of special meaning, one representing the settlement zone and the other a potentially important resource space in terms of subsistence, communication, and mobility. Therefore, we were interested in characterizing the visual landscape as seen from the shoreline and the lake on a more global level. We turned to cumulative viewshed calculations, a type of visiblity mapping, that consists of generating, and combining large groups of viewsheds (Gillings 2015). This approach offers a powerful set of tools to explore visual patterns on a global landscape scale allowing e.g. to explore prominence and hiddenness in a more systematic way (Gillings 2015; Verhagen 2018). One of the challenges of this approach however lies in the high requirements of computation time and data volume for even small surfaces.

We calculated cumulative viewsheds based on the shoreline and the middle line of lakes Attersee and Mondsee (Figure 3). The processing extent was limited to our research area. The analysis were carried out in ArcGIS 10.1. The basis for the visibility calculations was a 10 m DEM, observer points on the shore lines were extracted from Open Street Map data (Open Source Lake Polygons; one point every 50 m). The obersever height was set to 1.5 m. For our first level of explorative viewshed investigation we deliberately chose a very rough database to reduce computation time and data volume.

The viewshed map reveals for lakes Attersee and Mondsee a rather restricted field of vision, limited in the alpine part of the lakes by steep mountain ranges and in the alpine foreland by morainic walls (Figure 3). Only few of the areas lying beyond the directly adjacent mountain ranges and morainic hills are visible from the lake and the shoreline. Respectively only few areas in this space allow for a larger field of vision. The

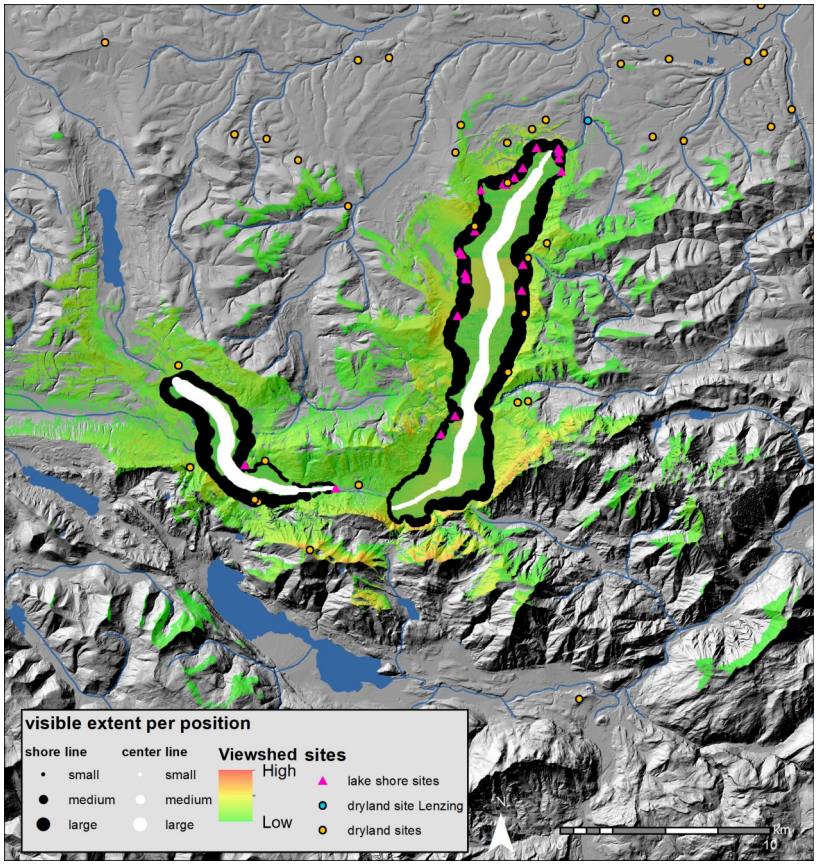

Figure 3: Combined cumulative viewshed map for lakes Attersee and Mondsee with all known lacustrine sites. Calculations are based on a 10 m DEM. Data source: Land Oberösterreich, CGIAR-CSI, Geofabrik GmbH and Open Street Map contributors. Map author: Julia Klammer.

visual landscape can be characterized as a closed world dominated by landscape elements such as the waterbody of the lake, mountain ranges, and moraines as well as areas of high visual connectivity. Seen on the level of the research area lakes Attersee and Mondsee, despite their size, do not represent important or even dominant visual elements. Also, the visual connectivity between the lake/shore area and the adjacent dryland areas, and particularly the alpine foreland, is low.

Putting these observations in relation with the spatial distribution of the 4th mil. sites shows that no site overlooks both, the lake and the wider hinterland area. The majority of the sites is located in the shore area of lakes Attersee and Mondsee and thus within the small world visual landscape described above. All other sites of this time period, and especially the newly discovered settlement located in Lenzing, have no visual connection with any of the lakes (waterbody or shore area). This also means that the 4th mil. settlement of Lenzing has no line of site with any of the settlements in the shore area of lake Attersee. To explore the influence of erosion on the visibility of the site, we performed further visibility analysis which aimed to determine the minimum height needed to be within the visibility range. These showed that at least 16 m of additional height on the spurn were necessary to come within view of the lake. Considering the low number of known 4th millenium dryland sites in the research area, we cannot rule out that the observed patterns are due to filter processes and the state of research. But we can demonstrate through diachronic comparison that positions allowing for an oversight of the lakes and the wider hinterland were not generally avoided during prehistory in the re-

search area. This type of mapping also allows for a systematic exploration of the landscape in terms of zones of prominence and seclusion. In our current work we focus on assessing the prominence and hiddenness of landscape elements of special interest such as natural pathways leading into the lakes as well as places of potential strategic value, e.g. overlooking natural pathways such as the region of Strass im Attergau.

Natural pathways and landscape connectivity

Mobility of neolithic communities has received growing attention over the last years (Leary and Kador 2016). The narrative has shifted from the idea of a static and unmoved sedentism to communities and individuals involved in complex mobility patterns. The lacustrine neolithic of the 4th millenium offers a great wealth of data on mobility patterns from local to supraregional level. We are especially well informed on the processes taking place on the site level in the region of the circumalpine lakes in France, Switzerland and Germany. The period stands out as one of intense mobility with a well documented settlement history characterized by short-lived settlements and varied subsistence strategies affording the managment and cultivation of very different landscape elements and on different spatial scales (Ebersbach 2013; Hafner and Suter 2003; Jacomet et al. 2016; Petrequin 2013; Schlichtherle 2011; Schlichtherle et al. 2004; Hafner, et al. this volume; Mainberger et al., this volume). On a supraregional level farreaching trade and communication networks are evidenced through e.g. the widespread distribution of the so called Mondsee copper.

At the present state of affairs the Mondsee group seems to fit well into these patterns. In certain aspects it shows especially strong indications for the connection with transregional networks. The role of the Attersee-Mondsee region as a hub for transregional communication and trade was discussed, controversially early on (Beninger 1961, pp. 148–153; Childe 1947, p. 291; Franz 1928, pp. 8–12, 299–307; Willvonseder 1963). And as recent research on the provenance of the Mondsee copper has shed new light on the material flows in the area (Frank and Pernicka 2012), the question of the status of this region and the Mondsee group within the transregional networks of this period remains a valid one. We aim to contribute to these questions through spatial analysis by assessing the accessibility and connectivity of the landscape within the research area and its connection to transregional pathways. A glimpse at the map shows that the research area has a potentially high connective value (Figure 1, Figure 2). It links two important natural environments with different resources and environmental conditions, the Alps and the alpine foreland. And it is characterized by a dense hydrological network. Rivers and lakes represent important natural pathways. Whereas the region's larger lakes represent pathways of foremost local and regional importance by connecting the lakeshore communities and the alpine with the forealpine zone. The rivers, especially the Ager (efflux of lake Attersee), connect the region through the Traun river to the Danube valley. It is important to note that the entire region drains to the north (see above). Mobility to the south into the alpine area and beyond can only intermittently make use of waterways via the lakes and is mainly connected to land transport. One important aspect in assessing the connectivity of a landscape is to consider combined land-water-transport. Recently Martin Mainberger

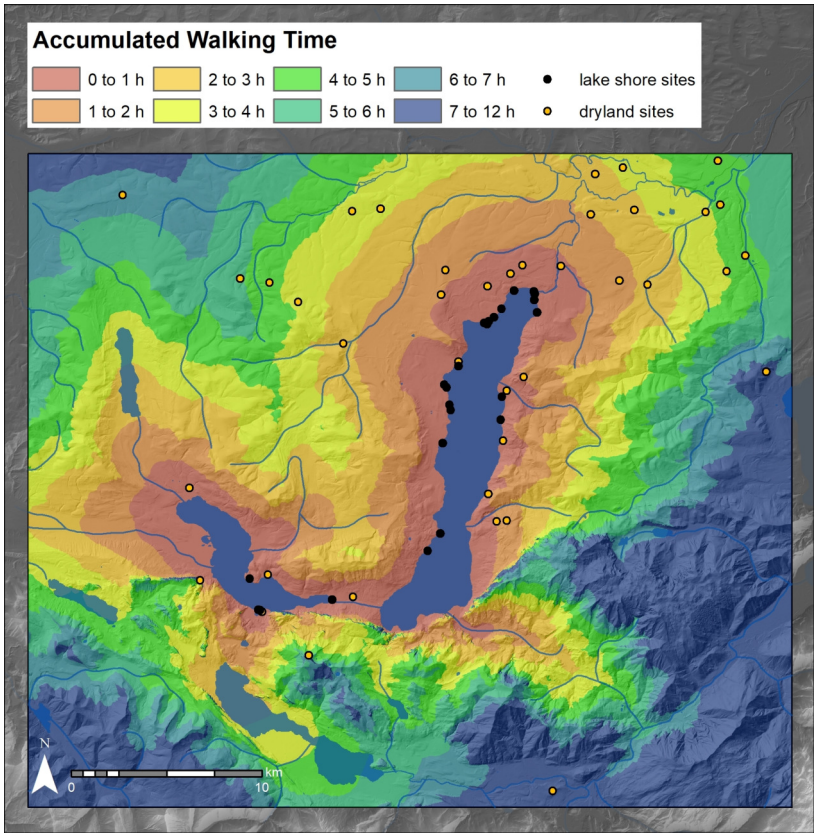

Figure 4: Cost surface map with all known lacustrine sites. Walking time was calculated from the shoreline of lakes Attersee and Mondsee with all known lacustrine sites. Cost distance calculations are based on a 10 m DEM, W. Tobler off-path. Data source: Land Oberösterreich, CGIAR-CSI, Geofabrik GmbH and Open Street Map contributors. Map author: Julia Klammer.

has adressed this topic by looking at the question of prehistoric portage activity across the European watershed in the Federsee region in southwestern Germany (Mainberger 2017).

To investigate the accessibility of the landscape in the Attersee-Mondsee region we used cost surface (dryland) and walking velocity calculations (dryland and water). This type of landscape classification and visualization is especially informative in areas with strong relief differences. The cost surface calculations were based on a 10 m DEM and started from the shore line of lakes Attersee and Mondsee. The processing extent was limited to our research area. For the calculation of the cost distance we used W. Tobler's function for off-path walking. The analysis were carried out in ArcGis 10.1. First and foremost the cost surface map highlights the differences in the relief (Figure 3). The steeper the terrain, the less ground can be covered in a certain amount of time. The smoother and less steep areas in the alpine foreland allow to cover considerably more ground on foot than the alpine areas. On lake Attersee the lacustrine sites cluster in this zone, but do not absolutely avoid steeper areas. Here the visual limit discussed above is reached in far under 60 min walking time. (The dryland settlement site in Lenzing can be reached in less than two hours from the northern end of lake Attersee.) The site of Scharfling on lake Mondsee connects easily to the more alpine lake Wolfgangsee within a two to three hour walk. Not only does this widen the site's hinterland to another lake but it also sets it up as a potential traffic node. Walking velocity also targets accessibility of the landscape, but here we have taken into account land and water travel. This form of landscape characterization highlights corridors that are characterized by flat terrain or water

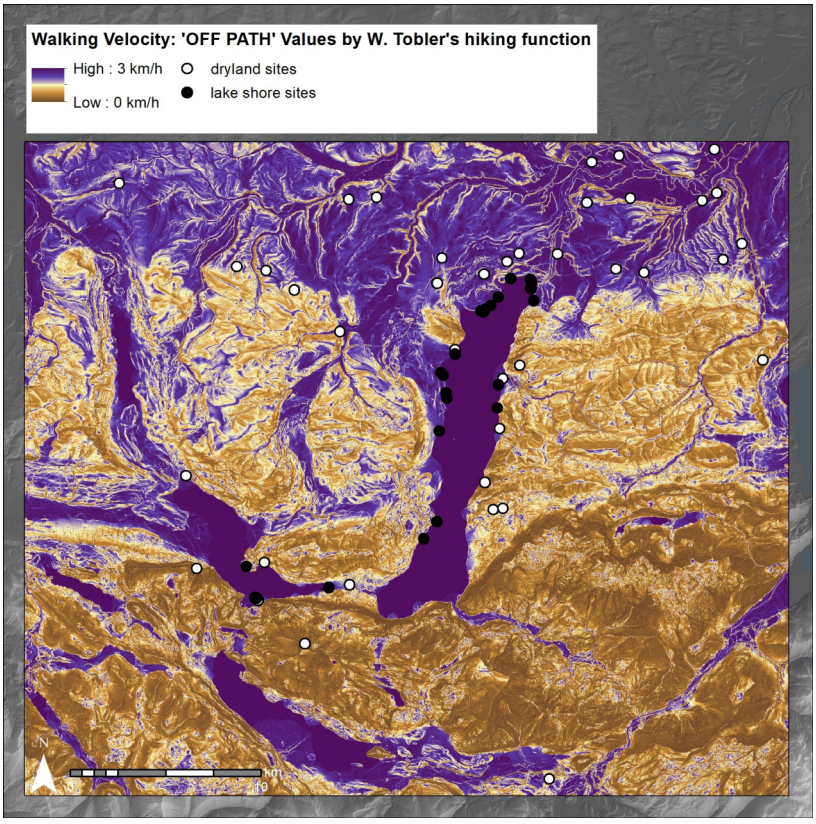

Figure 5: Walking velocity map with all known lacustrine sites. Calculations are based on a 10 m DEM. Data source: Land Oberösterreich, CGIAR-CSI, Geofabrik GmbH and geoland.at. Map author: Julia Klammer.

bodies or zones where both are connected (Figure 5). It also draws attention to areas of potential strategic value in terms of mobility control, such as the area of Strass im Attergau.

Combining the cost surface and walking velocity analysis highlights a potential combined water and land transport corridor connecting the alpine foreland west of lake Attersee with the eastern part of Mondsee via the Wanggau arriving at the site of Mooswinkl on the northern shore of lake Mondsee (Figure 2, Figure 4, Figure 5). Across the lake on the southern shore lies the site of Scharfling which connects via a low lying pass to lake Wolfgangsee and into the alpine landscape. Attention is also directed to another area on lake Mondsee, but for entirely other reasons. The western part of lake Mondsee is conspicuously free of lacustrine sites although in terms of topography it is very much comparable to the northern end of lake Attersee. The latter area is characterized by the highest density of lacustrine sites in the research area.

Site location choice (lacustrine sites)

Through our investigations into site location choice for the lacustrine settlements we target land use on the site level, but also aim at addressing inter-site connectivity. These investigations, which were conducted in the course of a Master thesis (Seidl da Fonseca 2019), encompass two work packages: i) site catchment analysis and ii) analysis of visibility patterns.

Site catchment analysis is a useful tool to investigate site location choice, but the approach comes with certain theoretical challenges, that need

to be taken into account (cf. Gross and Huber 2018, pp. 261–262). The classical site catchment model as proposed by Vita-Finzi and Higgs in 1970 (Vita-Finzi et al. 1970) was applied several times in lacustrine research (Benguerel et al. 2010, pp. 156–160; Jacomet et al. 1989, pp. 88–89; Winiger 1989, pp. 229–233). But as Eda Gross and Renata Huber have pointed out, the underlying concept of clearly delimited, autonomous, self-sustaining villages is problematic (Gross and Huber 2018). In fact, this model has come under severe criticism in recent years (Röder et al. 2013). A relational network model that focuses on the entire lake area with its adjacent hinterland as settlement and subsistence zone of a networked community has been proposed in its stead (Gross and Huber 2018). This approach is very promising as it allows for a much higher degree of dynamism in modelling land use and settlement history. In view of the proposed change in concept we suggest that the method of site catchment analysis might be operationalized for this new model as well. In fact a conceptual framework combining site level and landscape level perspectives seems well suited to achieve this purpose.

The site catchement analysis for the lacustrine Mondsee group sites is based on catchments determined through cost surface calculations. Within these catchments geofactor analysis will target slope, potential solar radiation and exposition. Land use based on historical maps will be qualitatively described and the relation to natural pathways analysed. Here we will only focus on the catchment sizes.

Catchment areas were calculated for 30 and 60 minutes for dryland and the water surface of the lakes and for dryland only. These calculations are based on a 5 m DEM. To determine the cost distance the off-path algorithm after W. Tobler was used. Speed of movement on water was equated to walking on flat terrain. The water surface was integrated into the catchment area to take into account the potential connectivity of water bodies and to acknowledge their potential territorial and economic importance (Figure 6). It has to be considered that the economic space of a settlement might not be restricted to one lake shore and the adjacent hinterland, but might extend across the water surface to other dryland zones easily reachable by water transport. The analysis shows that the catchment size of the various settlement sites varies, but not in direct relation to the size of the settlement. When the water surface is taken into account the catchment of some settlement sites changes distinctly, giving access to more resources (surface). The largest impact is on the potential connectivity as travel time is massively reduced. Otherwise a pattern known from other lacustrine settlement areas can be observed, especially in the more densely settled zones of lake Attersee, where catchment areas overlap strongly.

Viewsheds were calculated for every settlement site. The viewshed calculations are based on a 10 m DEM with an observer offset of 1,5 meters. The calculations were performed in ArcGis 10.1. In a first step the field of vision of every settlement site was characterized and quantified. The analysis shows that most sites have a wide view over the water surface, but a very restricted one on the land side. The viewshed of the sites is varied. On average the visual range of the sites at lake Attersee is wider than on Mondsee. On Attersee the sites with the widest view are located on the western (area of Abtsdorf) and eastern (Weyregg) shore at about mid length of the lake. Sites in small bays like Kammerl, Unterbuchberg and Kammer I have the most restricted view. For most of the sites even

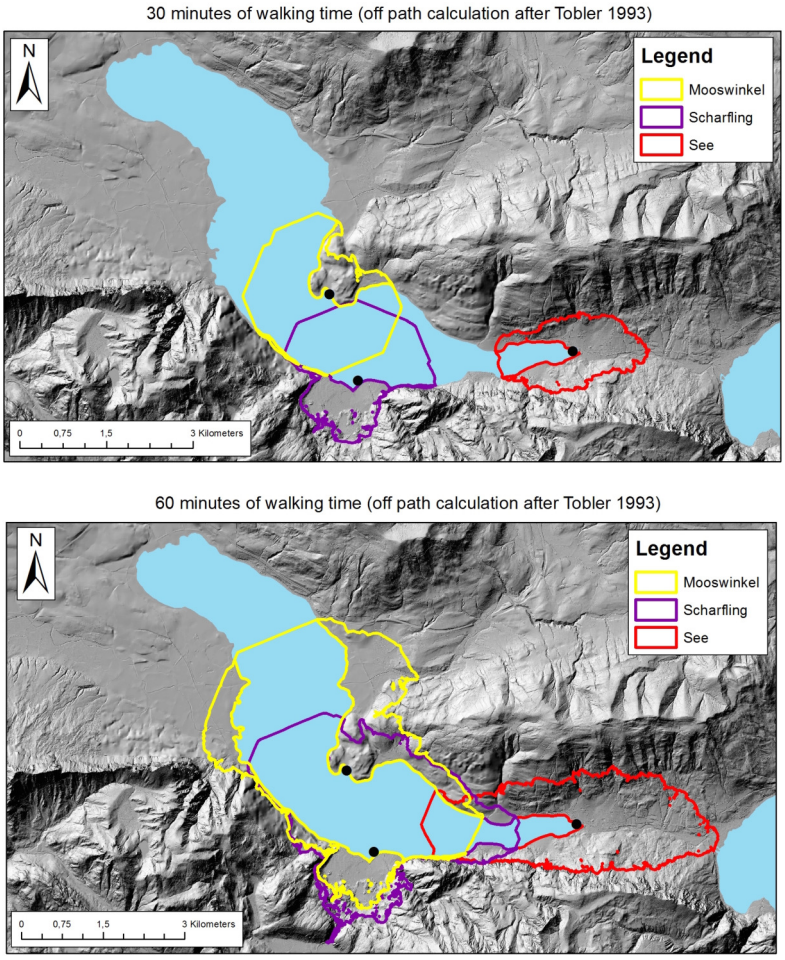

Figure 6: Catchment areas based on walking time (30 min, 60 min) for the lacustrine sites on lake Mondsee. Calculations are based on a 5 m DEM, W. Tobler off-path. Map author: Helena Seidl da Fonseca.

large parts of the terrain within the catchment areas of 30 minutes are not visible. An extreme example is the totally invisible hinterland of the site Litzlberg North I. The sites located at the efflux of the lake Attersee have a good overview of their direct environment, but not further. This of course corresponds to our observations of visual patterns based on the cumulative viewsheds. From a visual 'point of view' the lacustrine sites were more turned towards the lakeside and the opposite shore. Of course these observations are based on individual viewsheds. Cumulative viewsheds based on the catchment area will give a more detailed understanding of the visual landscape around these sites. The question of visual connectivity between the various settlement sites must be approached with caution, as the chronological framework is at present not resolved enough to assess the chronological relation of the settlements. Under the theoretical assumption of all sites being settled at the same time, the settlements of Abtsdorf and Aufham would have been the most prominent or visually the most connective ones. The sites of Misling I and II the least. The sites of Abtsdorf stand out for several reasons, they have the widest viewshed and the highest number of visual contacts with the other lacustrine sites (Figure 7). In addition, they are located in an area where the

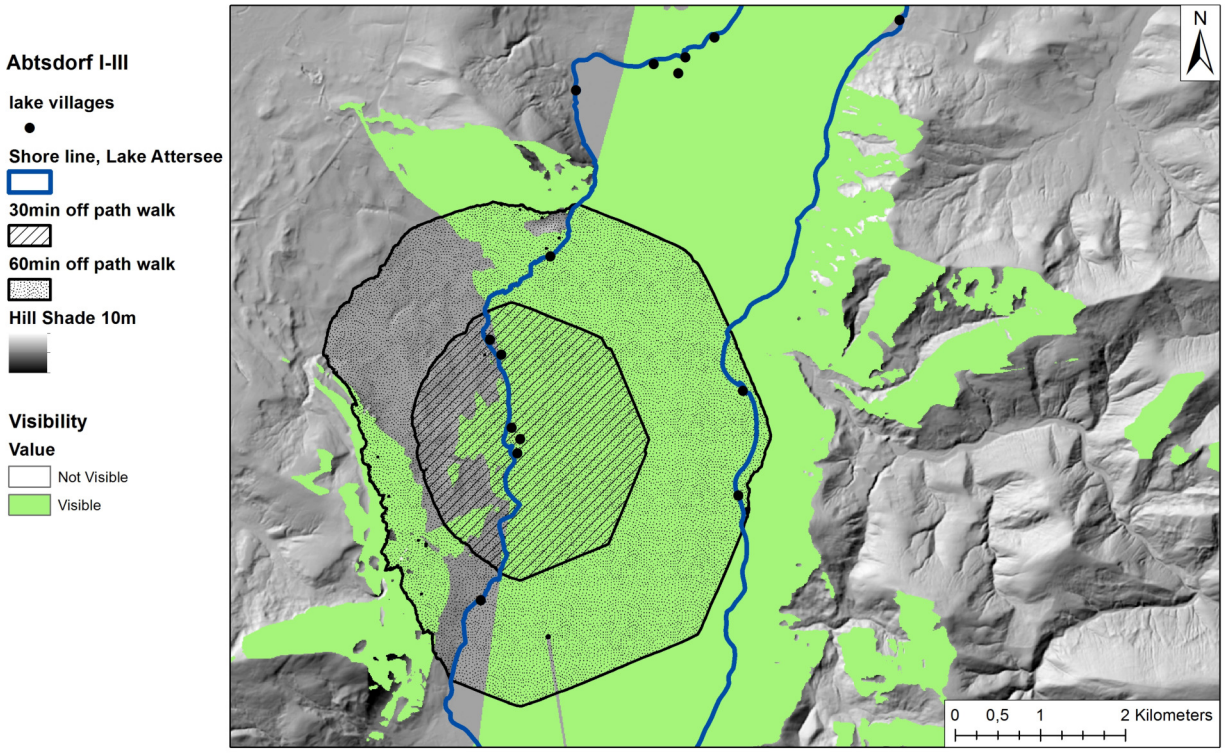

Figure 7: Visibility and cost surface maps calculated for the settlement area of Abtsdorf I-III. Cost distance calculations are based on a 5 m DEM, viewshed calculation is based on a 10 m DEM, with an observer off-set of 1,5 m. Observer point and starting point for the cost distance calculations are set at the center of the combined settlement zones. Map author: Helena Seidl da Fonseca.

relief allows to cover much ground in the hinterland and connect to one corridor of high walking velocity leading into the alpine foreland in the direction of e.g. Strass im Attergau. Current work addresses the quality of the visual range, by classifying the visual field according to Higuchi's classification of foreground, middleground, and background (Wheatley and Gillings 2002, pp. 15–24).

Conclusion

By targeting visual patterns, landscape connectivity and site location choice we are working on characterizing 4th millenium human-environment relations through a 'spatial lense'. The applied methods represent powerful tools in addressing past human landuse, especially as they allow for the combination of different perspectives, such as site level and landscape level. Through the application of the described analysis areas of special topographic properties have come into focus. These need to be investigated further in the field and through diachronic analysis.

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