The use of lidar-derived relief models in archaeological topography
The Kobarid region (Slovenia) case study

Benjamin ŠTULAR

Izvleček

V prispevku smo ovrednotili uporabnost visoko ločljivega digitalnega modela reliefa, ki je bil pridobljen z lidarskim snemanjem v kobariški mikroregiji, kjer je bilo lidarsko snemanje narejeno leta 2007. Za pričujoči prispevek so enako pomembni tudi odlični arheološki podatki, ki smo jih črpali iz obstoječih podatkovnih zbirk (*ARKAS*, *RNKD*). V jedru prispevka predstavljamo sedemnajst registriranih arheoloških najdišč, šest najdišč s posamičnimi najdbami in tri sklope zunajnajdiščnih arheoloških podatkov. Ločeno so predstavljeni že znani arheološki podatki in novi podatki, ki smo jih pridobili iz modela reliefa. Tako si lahko bralec ustvari objektivno sliko o pomenu lidarskih podatkov. V nadaljevanju je predstavljen kratek študijski primer poznoantičnih naselbin, v katerem skušamo predstaviti različne načine uporabe lidarskih podatkov. V tej raziskavi nismo odkrili novih arheoloških najdišč (iz obdobij do zgodnjega srednjega veka), smo pa dokumentirali ogromno količino zunajnajdiščnih podatkov.

Ključne besede: arheologija, lidar, DMR, arheološka topografija

Abstract

The aim of this article is to evaluate the extent and nature of the new archaeological information that can be extracted from lidar-derived high-resolution relief models. The lidar data from the Kobarid region (Slovenia) derives from 2007 and has been used in the form of a relief model with a half-metre grid. The availability of excellent archaeological data gathered in the publicly available databases (*ARKAS*, *RNKD*) has been of equal importance for this article. The focus of the article is the presentation of seventeen archaeological sites, six find-spots and three off-site complexes. The previously known data are presented separately from the lidar-derived information in order to enable the reader to reach objective conclusions regarding the importance of lidar-derived data. This is followed by a case study on the settlements from the Late Antiquity period focusing on the endorsed methods of the lidar-derived data use. Although no new archaeological sites (from periods until the Early Middle Ages) have been discovered, a large amount of new data pertaining to the off-site archaeology has been gathered.

Keywords: archaeology, lidar, DEM, archaeological topography

INTRODUCTION

In 1984–1985, Thomas Sever of NASA flew over the area around the volcano of Mount Arenal ... (and) *scanned the area using radar, infrared photographic film, and a device called lidar (light detection apparatus)*(Renfrew, Bahn 2000; cf. Sheets, Sever 1988). As far as this author is aware this was the first use of Airborne Laser Scanning (ALS), also referred to as lidar (Light Detection and Ranging) in archaeology. The somewhat cumbersome description of lidar *apparatus* in year 2000 is just as interesting, though. It is a reminder of just how young the use of lidar in archaeology really is, with the first dedicated articles appearing only in the 2000s (e.g. Motkin 2001; Holden, Horne, Bewley 2002; Barnes 2003; van Zijverden, Laan 2004). The number of archaeological applications of lidar data is growing steadily and rapidly in recent years. Mostly we are still seeing reports on the mapping of archaeological features (Barnes 2003; Bewley, Crutchley, Shell 2005; Bofinger, Kurz, Schmidt 2006; Corns, Shaw 2009; Harmon et al. 2006; Howard et al. 2008; Powlesland et al. 2006; Sittler 2004) with some articles focusing on the detection of archaeological remains in forest (Chase, Chase, Weishampel 2010;

Devereux et al. 2005; Doneus, Briese 2006; Gallagher, Josephs 2008; Kokalj 2008; Risbøl, Giersten, Skare 2006; Sittler, Schelleberg 2006). Due to the high data resolution the lidar data are often integrated with geoarchaeological prospection and evaluation (Brunning, Farr-Cox 2005; Buteux, Chapman 2009; Carey et al. 2006; Challis 2005; Challis 2006; Challis, Howard 2006, 23–36). We are just witnessing the first examples of the lidar-derived data being fully integrated into a full-scale archaeological research (Budja, Mlekuž 2010; Chase et al. 2011).

All authors include some methodological introduction, and a series of articles on the visualisation of terrain models is now available (Devereux, Amable, Crow 2008; Hesse 2010; Kokalj, Zakšek, Oštir 2011). Encouragingly, the first critiques of overly high expectations are also emerging (Crutchley 2009). The use of lidar in archaeology is being included in the latest remote sensing (Parcak 2009, 76–77, 104–105) and geophysical prospection (Campana 2009; Powlesland 2009; Watters 2009) overview volumes; the rather brief mentions are another reminder that lidar is still a relatively new tool in archaeology. The latter is, alas, further emphasised by the lack of any theoretical consideration within the landscape archaeology (cf. Head 2008; Johnson 2007). Some theoretical considerations have appeared, though, within geoarchaeology (Brown 2008).

From this brief overview alone the rapidly expanding use of lidar-derived data in archaeology is evident.

Airborne lidar is a remote sensing technique using airborne laser scanning systems. It consists of an active laser beam being transmitted in pulses from an aircraft and the returning reflection being measured. The precise location of the sensor array is known due to a combination of Global Positioning System (GPS) and the Inertial Measurement Unit (IMU) mounted in the aircraft. Using the principle of measuring distance through the time taken for a pulse of light to reach the target and return, it is possible to record the location of points on the ground with a very high degree of accuracy. Airborne lidar, therefore, collects very large quantities of high precision three-dimensional measurements in a short time (Crutchley, Crow 2010, 4–5). These point data are subsequently processed in three steps. First, the adjustment of the scan strips, with an eventual recalibration/correction of system parameters is performed. Then, the automatic filtering of the points – to detect the bare terrain – and the quasi-automatic segmentation of points – to classify the point dataset in different classes – is performed. In some cases and at great expense, this is followed by the interactive 3D modelling, which is needed in order to enhance the structure of the data. The three-dimensional geometric information provided from laser-scanned points is the essential result of this surveying technology and it enables the creation of high-resolution Digital Surface Models. The filtering of the natural/artificial objects allows the bare ground topography to be obtained (Doneus et al. 2008). The latter is used in the majority of archaeological applications such as survey and archaeological prospection, since the use of lidar intensity data is still in the experimental phase (Carey et al. 2006; Challis et al. 2011).

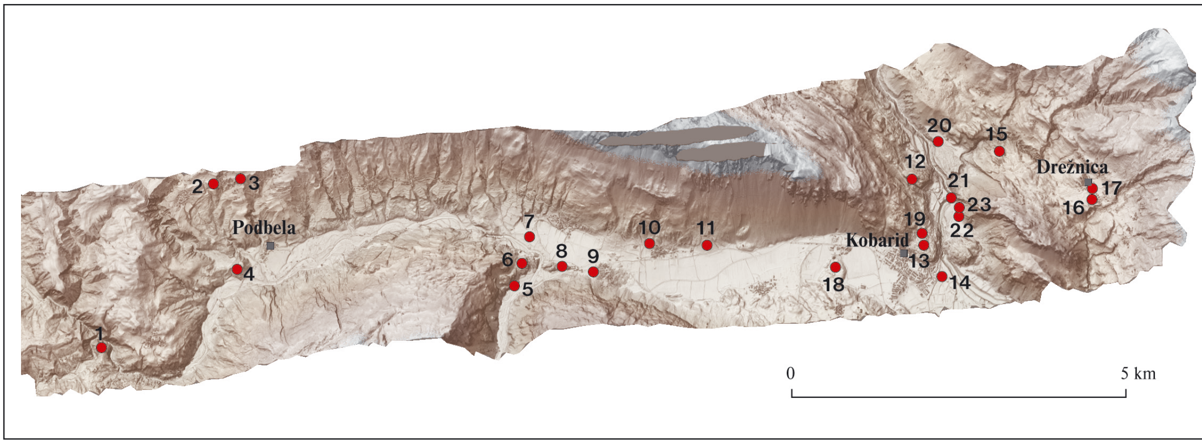
First, the terminology pertaining to the digital models of ground topography needs elaborating since its use in archaeological publications is not uniform (Chase et al. 2011).

A digital elevation model (DEM) is a continuous surface that consists of height or elevation values – with respect to a specific reference – as a grid. A DEM stores terrain elevation data (surface height) by means of a raster. The digital terrain model (DTM) is a continuous surface that, beyond height or elevation values, also consists of other elements that describe a topographic surface, e.g. slope, aspect, curvature, gradient (Burrough, McDonnell 1998; Podobnikar 2005). A DTM can be stored in different ways, for example as a set of contour lines or as a TIN.

A related term is the digital surface model (DSM). This term refers to a general expression for any mathematically defined surface, and is widely used to describe a basic product of lidar, photogrammetric terrain modelling, etc. A DSM includes buildings and vegetation cover, as well as natural terrain features such as temporal snow cover (Podobnikar 2008). In this article the use of lidar-derived DEM of bare ground topography is discussed.

METHODOLOGY

The aim of this article is to evaluate the extent and nature of the new archaeological information that can be extracted from lidar-derived high-resolution DEMs. This article differs from most of the lidar applications in archaeology. The studies focusing on comparison of the information derived from archaeological topography with information obtained from lidar-derived data are scarce (Bewley, Crutchley, Shell 2005) and none is focused on heav-



Karta 1: The sites in Kobarid region, with the cat. numbers as they appear throughout the article.
Map 1: Arheološka najdišča v okolici Kobarida, oštevilčena enako kot v katalogu in besedilu.
1 Gradec, **2** Pod cerkvijo, **3** Na mlakah, **4** Sv. Helena, **5** Turjeva jama, **6** Sv. Volar, **7** Kred, **8** Der, **9** Molida, **10** Na gomili, **11** V laščah, **12** Tonovcov grad, **13** Gradič, **14** Mlekarna Planika, **15** Veliki gradec, **16** Sv. Jurij, **17** Grad, **18** Kobariško blato, **19** Skrinjca, **20** Jajnkovec, **21** Za gradom, **22** Čebelnjaki, **23** V Mevcah.

ily forested mountainous areas with ample previous archaeological research. Most of the published studies are focusing on non-mountainous areas, and so far the majority stems from Great Britain and Germany. This study is similar to – but broader than – the comparison of aerial photography and lidar-derived data in forested areas (Crutchley 2009).

For this purpose the Kobarid region (Slovenia) has been analysed (*map 1*). Kobarid (Italian: *Caporetto*; German: *Karfreit*) is a town and a municipality in the upper Soča/*Isonzo* valley, western Slovenia. Geographically it is on the border between the Mediterranean and the Alps (e.g. Erhartič 2010, 299). The valley floors at about 250 metres a.s.l. are warmer than average Alpine valleys due to the proximity of the Adriatic sea. The same proximity is also a cause for the above average rainfall (*ARSO* 2006). But the climate dramatically shifts to colder in the surrounding mountains exceeding the height of 2000 metres. The research area is characterised by very rough geomorphology with 45 percent of the area having slopes above 25 degrees. The area has three natural passes towards the Mediterranean, the valley of the Soča River to the south of Kobarid, and the two branches of the Nadiža valley from the spring to the point where it flows into the Friuli plain. In the north the Predel/Predil pass connects the area with the Alpine interior.

The laser scanning of the 56.88 km^2 area was commissioned and processed with a clear focus on archaeology in early March 2007 when the vegetation was still dormant, the fallen leaves were compacted and the ground was without snow cover. The conditions were revealing the bare ground topography to the maximum degree. Filtering of the lidar point cloud was performed with REIN, Repetitive Interpolation algorithm (Kobler et al. 2007). Algorithm settings were optimized to remove only the vegetation cover. The filter therefore preserved buildings, walls, dikes and trenches, as well as retaining some spruce trees where the laser beam did not reach the ground (Kokalj, Zakšek, Oštir 2011, 268–269). All analyses used in this article have been performed on lidar-derived DEM with a 0.5 metre grid.

For this article the long and fruitful tradition of archaeological research in this area is of equal importance. The oldest archaeological data stem from the late 19th century and the first decade of the 20th century, and already saw the synthesis on prehistoric hillforts (Marchesetti 1903). Due to the archaeological topography in the last decades – studied foremost by Nada Osmuk, Miha Mlinar and the team led by Slavko Ciglenečki – there is ample archaeological data accessible in archaeological databases (see below).

The central part of this article is devoted to the description of archaeological sites. The focus is on the on-site data (i.e. archaeological sites) since in-depth discussion of the off-site data (e.g. pathways, field boundaries, artefact scatters) requires much more extensive text including theoretical considerations and further case studies. Nevertheless, the off-site data are briefly presented in the catalogue for further consideration. Careful attention has been paid to delimiting the lidar-derived data from previously known data. Therefore the first part of each site description

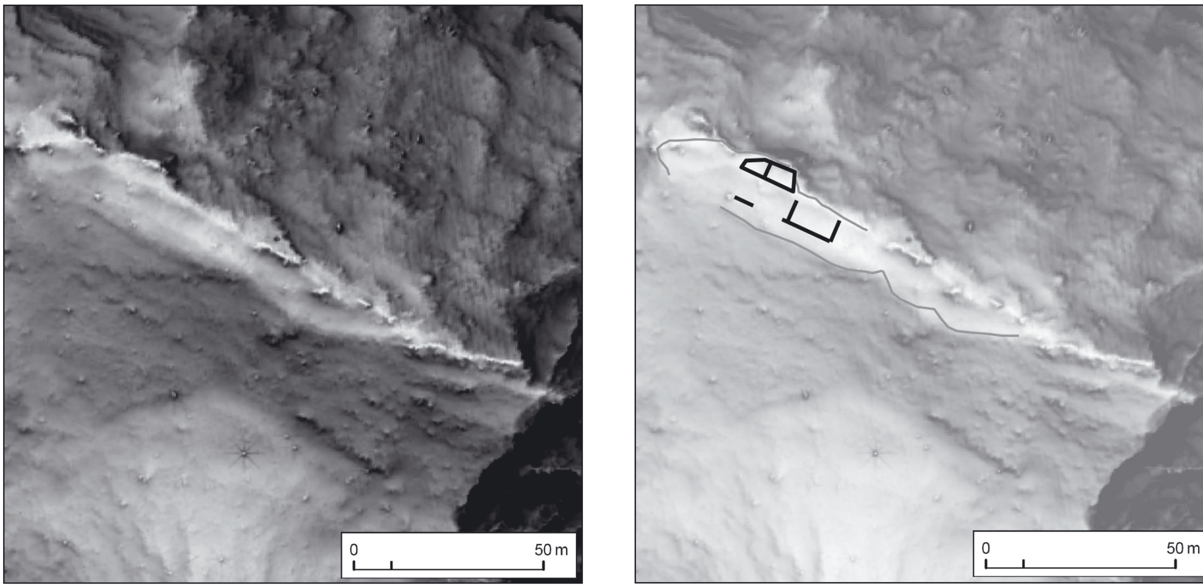


Fig. 1: Gradec (cat. no. 1), lidar-derived DEM (unless otherwise mentioned all images appearing in this article use a blend of analytical hillshading, slope gradient and Sky view factor) and the plan of the archaeological features.
Sl. 1: Gradec (kat. št. 1), DMR izdelan iz lidarskih podatkov (razen kjer je izrecno omenjeno, so vse slike v članku prikazane z mešanico analitičnega senčenja, naklonov in t. i. faktorja odprtosti neba) in načrt arheoloških struktur.

presents the previously known data (*name*, *description*, *location*, *communications*, *previous research*) including author's interpretation (the second paragraph of the *description*). The lidar-derived data are described and commented at the end (*potential features in lidar-derived data*, *archaeological interpretation of lidar-derived data*). The intention of this part of the article is to enable the readers to make their own conclusions. For this purpose we are presenting the lidar-derived DEM visualizations separately from interpretations in the manner established for aerial photography (e.g. Aston 2003).

Following this is a case study analysing the lidar-derived data of the settlements from the Late Antiquity period. Rather than in-depth archaeological analysis, the aim of this part is to demonstrate the full potential of lidar-derived data even for the research fields that are already excellently researched. At the end the results are discussed with the focus on the future use of the lidar-derived data applications in archaeology.

THE ARCHAEOLOGICAL SITES
(*map, figs. 1–26*)

The names of the sites are used as they appear in *ARKAS* (*Arheološki kataster Slovenije* = Archaeological cadaster of Slovenia) or alternatively – in case of sites 7 and 17 not featured in *ARKAS* – as it appears in *RNKD* (*Register nepremične kulturne dediščine* = the heritage registry). ID refers to *ARKAS* identification number. The EŠD (Slo. *evidenčna številka dediščine*; heritage No.) refers to *RNKD*. For the sites that are not featured in both databases only the appropriate number is shown.

A. Archaeological sites and recorded areas with archaeological potential

1

Name: **Gradec** near **Logje** (ID 010203.01; EŠD 5026)

Description: Hill fort or fortified refuge of the Late Antiquity period – N. Osmuk's and S. Ciglenečki's interpretation respectively – has been reported based on the barely recognizable traces of ground flattening and a find of a 6th c. AD *fibula* recovered from illegal metal detecting (Osmuk 1985a; Ciglenečki 1997, 25; Cvitkovič 1999, 17).

The interpretation is based on scarce micro topographic evidence and one find. Further evidence is needed to confirm the interpretation.

Location: The Gradec hill rises over the confluence of the Legrado stream and the Nadiža, the latter no more than a stream itself in this uppermost flow. With a cliff on the eastern side and very steep

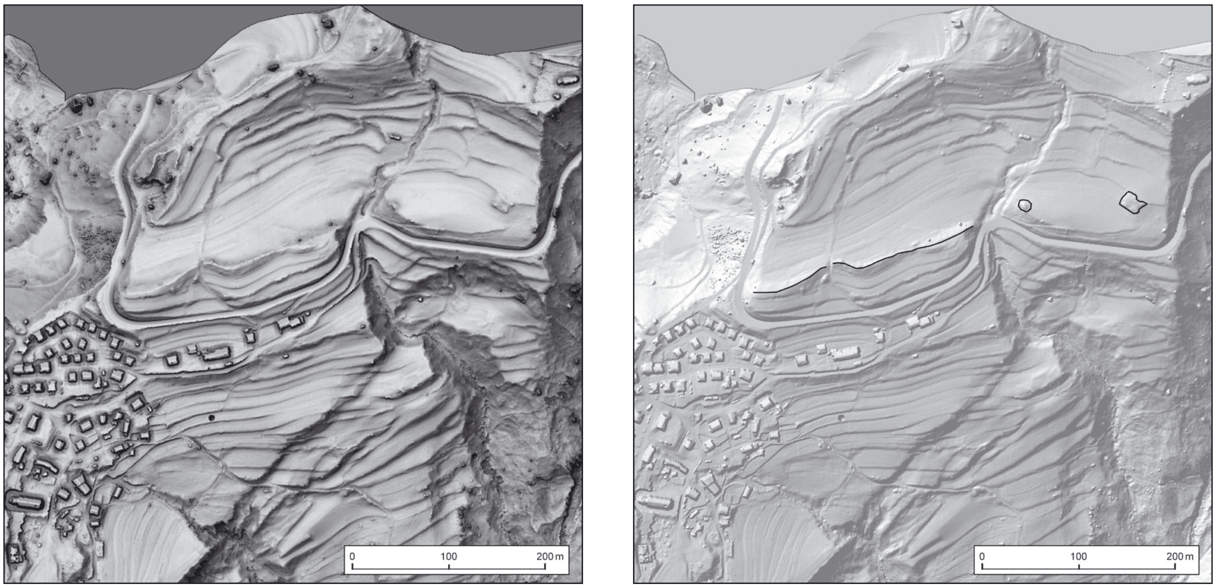


Fig. 2: Pod cerkvijo (cat. no. 2), lidar-derived DEM and the plan of the archaeological features.
Sl. 2: Pod cerkvijo (kat. št. 2), DMR izdelan iz lidarskih podatkov in načrt arheoloških struktur.

slopes on other sides, combined with a remote location, the location needs no fortifying. At the time of this research the site and its surroundings were covered in dense vegetation, predominantly young broadleaf forest.

Communications: The only possible access to the hill summit is from the south via a hill saddle and long slope. No historic routes are known to exist in this area. However, continuing along the Nadiža and onwards towards the north, one reaches the Friuli plain without an excessive effort, as confirmed by optimal path modelling (cf. Štular 2011a).

The site has no visual communication with other sites but is visible from the modelled optimal path.

Previous research: Topographic research (Osmuk 1985a; Ciglenečki 1997, 25; Osmuk 1999a) has not been followed up. The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Earthworks, e.g. terracing.

Archaeological interpretation of lidar-derived data (*fig. 1*): The small elongated plateau on the hilltop is 110 m long and 4.5 to 12 m wide and covers an area of 802 m^2. It is very rugged with only 105 m^2 of the area having a slope gradient under 10 degrees. The man-made alterations mentioned by Ciglenečki (1997, 25) are recognizable in the form of one building-like structure on the northern edge of the hilltop. Additional perpendicular features can be recognised in the central part of the plateau. These possibly delimit two built or enclosed areas measuring 5.5 by 12.6 and 6.2 by 13.1 m; the size is consistent with buildings on nearby hilltop settlements (cf. **4**, **12**). Also, the sections of these features are more reminiscent of the collapsed walls than of terracing (cf. **15**).

The described features fill the entire width of the hilltop; had these been parts of buildings the communication area would have been scarce indeed. Although certainly man-made and extremely unlikely to be of a prehistoric date, as a whole these features bear little resemblance to the confirmed Late Antiquty Period settlement (**12**) or fortified refuge (**15**).

2

Name: **Pod cerkvijo** near **Sedlo** (ID 010206; EŠD 5032)

Description: Cremation burials of possible Prehistoric or Roman period date have been reported, but the finds were never examined by archaeologists and are now lost. On the neighboring location (**3**) a settlement has been suggested based on the geomorphology.

The interpretation is based solely on scarce topographic evidence and needs further evidence.

Location: On the southern slopes of the Kobariški Stol mountain high above the narrow Nadiža River valley. At the time of this research the site was being used as a meadow. The surroundings were covered in dense vegetation, predominantly young broadleaf forest.

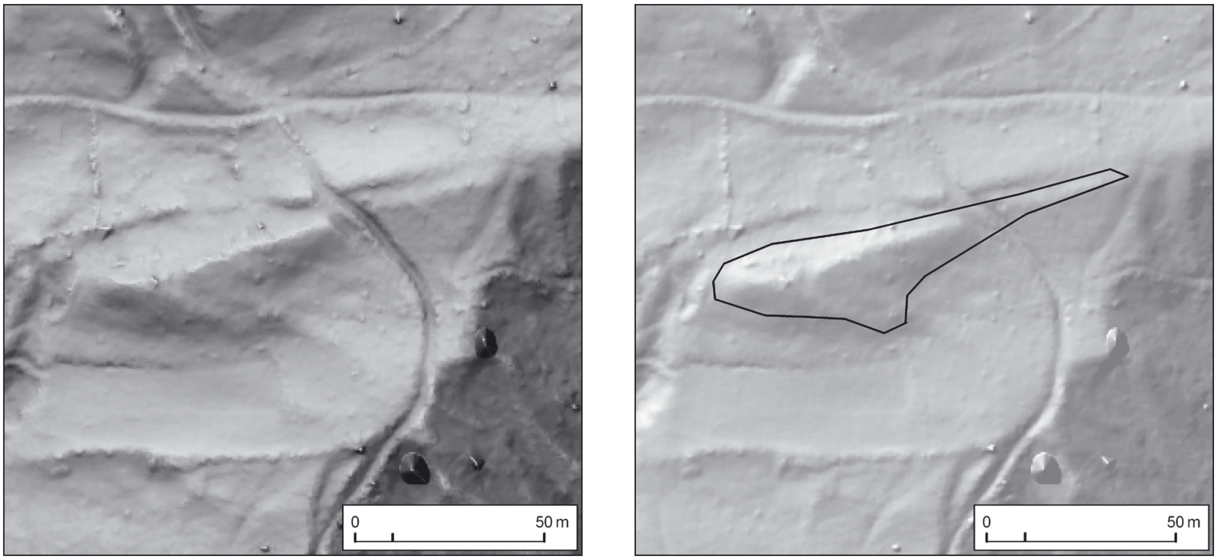


Fig. 3: Na mlakah (cat. no. 3), lidar-derived DEM and the plan of the archaeological features.
Sl. 3: Na mlakah (kat. št. 3), DMR izdelan iz lidarskih podatkov in načrt arheoloških struktur.

Communications: The "shortcut", i.e. secondary route, of the Friuli plain – Carinthia track bypassing Sedlo and crossing the Kobariški Stol (see **5**) as conjectured by C. Marchesetti passes nearby in the south – north direction. A Bronze Age axe find near Žaga on the northern foothills of the Stol Mountain is used as an argument for the existence of this track, but the use of the track, for long distance travelling is not likely (Marchesetti 1893a, 319; cf. Štular 2011a). The road gradually climbing the slopes from the Kred village in the east – west direction is shown on the 18th c. map and seems to be of post-medieval date.

The site has an overview of the two closest sites (**3, 4**).

Previous research: Topographic research in the 1980s (Osmuk 1985b) and late 1990s (Cvitkovič 1999, 19) has not been followed up.

Potential features in lidar-derived data: Earthworks, e.g. ramparts.

Archaeological interpretation of lidar-derived data (*fig. 2*): Up to 2 m high and 12 m wide, the earthwork is preserved in the length of 234 m situated on the lower end of the agricultural terraces in the midst of field boundaries of possible medieval age (*terminus ante quem* 1822). The earthworks follow the contours of the terrain. This earthwork is significantly larger compared to the surrounding field boundaries, both in height and width. However, the earthwork does not enclose the area since it is limited to one side. Also, the area is not located on the hilltop but rather on the slope of the mountain. As such, the location is dissimilar to prehistoric enclosures typical of this area (**6**, **13**).

Although the earthworks are likely to be man made, this site is neither hilltop nor enclosure.

3

Name: **Na mlakah** near **Homec** (ID 010202.01; EŠD 5019)

Description: Roman period settlement – *mansio* or *villa rustica* – is conjectured based on the surface finds of pottery and brick (Osmuk 1997, 11).

The interpretation is based on scarce finds and needs further evidence.

Location: At the time of this research the site and its surroundings was covered in dense vegetation, predominantly young broadleaf forest. See **2**.

Communications: See **2**.

Previous research: Topographic research in the 1980s (Osmuk 1985b) has not been followed up.

Potential features in lidar-derived data: Earthworks, e.g. pre-medieval land clearance, and path network hub.

The site has an overview of the two closest sites (**2, 4**).

Archaeological interpretation of lidar-derived data (*fig. 3*): An earthwork 108 m in length, up to 25 m wide and up to 1.56 m has been detected. Size, form and location are similar to the Pod cerkvijo site (**2**).

Although the earthworks are likely to be man made, this site exhibits no features reminiscent of a settlement.

4

Name: **Sv. Helena** near **Podbela** (ID 010204.01/.02; EŠD 5028)

Description: The site has been described as a prehistoric hilltop settlement without ramparts, but occasional finds and reports since the 1990s have revealed Late Roman period finds (Osmuk 1992; Osmuk 1999b; Knific 2004; Ciglenečki, Modrijan, Milavec 2011, 33–52).

Whereas there is no actual evidence for the prehistoric occupation, Late Roman / Late Antiquity Period finds present convincing evidence for use of the site in this period.

Location: A small hill rising above the Bela stream and Nadiža River confluence. The top of the hill has been flattened. The steep slopes on all four sides are not unapproachable and have been negotiated by paths from three sides. At the time of this research the site and its surroundings were covered in mixed vegetation consisting of meadows with patches of young broadleaf or coniferous forest.

Communications: See **1**.

The site has an overview of two sites on the Stol Mountain slopes (**2, 3**) and of the Nadiža River valley towards the east.

Previous research: The site was recognised in 1892 by C. Marchesetti (1893b, XIV). In the next century it was scarcely researched (Vuga 1974a) and it was only in the 1990s that illegal metal detecting and unauthorized rebuilding of the medieval church prompted visits from archaeologists that yielded new data (Osmuk 1992; Osmuk 1999b). The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Earthworks, e.g. individual buildings.

Archaeological interpretation of lidar-derived data (*fig. 4*): A partial settlement plan with six buildings including interior divisions has been recognized on the southwestern part (45%) of the site that is nowadays heavily forested (Kokalj, Zakšek, Oštir 2010). The northeastern part of the site (55%) exhibits no earthworks since it has been levelled, most likely at some time during or after the time when the still standing late medieval church was built. The reconstructed sizes of two- or three-cell buildings are on average 7.4 by 18.7 m and on average cover an area of 110 m^2. Possible disturbed remains of two additional buildings in the form of two elongated mounds (15.5 by 6.2 m and 10.1 by 59 m, up to 0.4 m high) have been recognized south of the church.

Several sections of the defence wall have been recognized on the northwestern side (22, 11.2 and 46.1 m long; 0.2 to 0.3 m high and up to 1.8 m wide) and on the southeastern side (29.5 and 9.8 m long; 0.1 to 0.3 m high and up to 3.8 m wide). The entire enclosed area is 7838 m^2 large with a 404 m long perimeter.

At present 2 paths lead to the summit. The northwestern approach connects a modern crossroad with the church entrance, and clearly post-dates the modern road. The southeastern approach connects the nearby hamlet of Podbela with the church; it cuts through the two elongated mounds and hence it post-dates the settlement ruins. The western approach is no longer in use since most of it collapsed in an avalanche clearly predating the modern road. This approach does not lead towards any existing settlement. The path is 1.5 m wide with a 22 to 25 degrees incline. It has been cut into the slopes and therefore built with considerable effort. This path is most likely the remnant of the approach contemporary with the settlement. This conclusion is underpinned by the absence of any other traces reminiscent of the built track that any settlement would require.

During the ground-truthing (Z. Modrijan and T. Milavec, 2.6. 2008) small fragments of brick, pottery and glass have been recovered that could only be broadly attributed to the Antiquity period (Roman, Late Roman or Late Antiquity period). The observations confirmed that the disturbed remnants are indeed stonewalls debris. Parts of a defensive wall have been recognized on the northern and western side where they are cut through by modern paths. At the western side the original wall termination is recognizable, confirming that this had been the original entrance to the settlement.

5

Name: **Turjeva jama** near **Kred** (ID 010610.04/05; EŠD 5031)

Description: Pottery finds collected on the ground surface inside the cave are dated to the period between the 14th and 11th centuries BC. The interior of the cave is interpreted as a cult area for the inhabitants of the presumed contemporary settlement (**6**), as is indicated primarily by the hoard of bronze objects also discovered at the site. The Bronze Age pottery, however, most likely arrived in the cave through a water channel from the settlement (Čerče, Šinkovec 1995, 221–223; Knavs, Mlinar 2005; Pavlin 2006, 71).

The date and interpretation of the hoard are convincing. In this author's opinion, however, the interpretation of the pottery finds needs further examination.

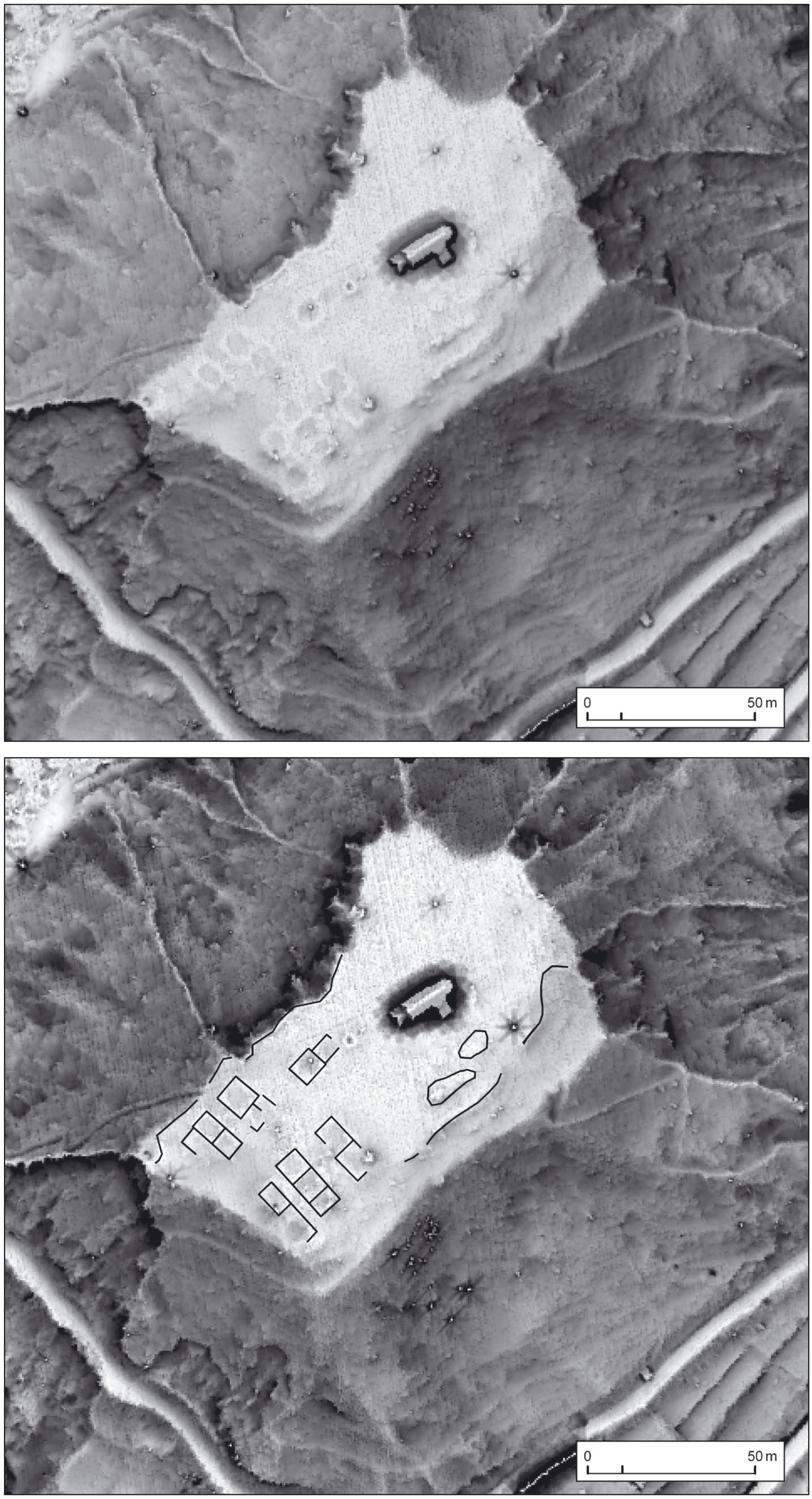


Fig. 4: Sv. Helena (cat. no. 4), lidar-derived DEM and the interpretative plan of the archaeological features.
Sl. 4: Sv. Helena (kat. št. 4), DMR izdelan iz lidarskih podatkov in interpretacija arheoloških struktur.

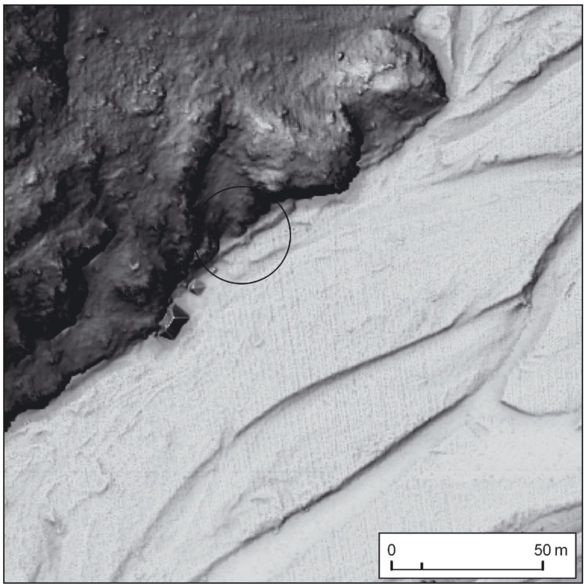


Fig. 5: Turjeva jama (cat. no. 5), lidar-derived DEM.
Sl. 5: Turjeva jama (kat. št. 5), DMR izdelan iz lidarskih podatkov.

Location: On the right bank of the Nadiža River, adjacent to the hamlet of Robič (also see **9**). The entrance into the cave is situated on the border of the slopes of the Mija Mountain and the gravelly Nadiža River floodplain. At the time of this research the site and its surroundings were covered in dense vegetation, predominantly young broadleaf forest.

Communications: The site is situated on the crossroads at the Nadiža valley bend, where the historic route from Čedad/Cividale exits the narrow valley and splits into three directions: towards the east as a Friuli plain (Čedad/Cividale)-Kobarid (**12, 13**)-Bovec-Predel/Predil-Carinthia route; towards the north as a shorter variation of the same route via Kobariški Stol mountain; and continuing towards the west along the Nadiža River.

The site has very limited visibility over the immediate surroundings and parts of Der (**8**) hill.

Previous research: The site was detected and excavated in the 1880s by C. Marchesetti. In 1992 a Bronze Age hoard was recovered after illegal metal detecting; later, pottery finds have been collected on the site (see Knavs, Mlinar 2005, 59–60 with bibliography). The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Possible features outside the cave, paths leading to the cave.

Archaeological interpretation of lidar-derived data (*fig. 5*): No features have been recorded.

During the ground-truthing (B. Štular and E. Lozić 19.–22.1. 2011) no additional data have been recorded.

6

Name: **Sv. Volar** near **Kred** (ID 010610.06; EŠD 9266)

Description: C. Marchesetti first described the site as a well-preserved prehistoric hillfort with double ramparts and Bronze Age pottery finds. A century later, additional ramparts were reported on the western slope (Osmuk 1997, 9) and some late Bronze Age finds were recovered from illegal metal detecting (Bratina 1994–1995). In 2003 several Early Medieval iron tools were recovered from the site, but the context and exact location of the finds are ambiguous (Knavs, Mlinar 2000–2004). In 2007 S. Ciglenečki recorded prehistoric shards on the lower plateau approximately 50 m north-east of the church. On the small plain between northern slope of the hill and the Nadiža River a cemetery belonging to the settlement is conjectured (Osmuk 1999c). The church dedicated to St. Hilarius and Tacianus standing on the hill summit was first mentioned in the written sources in 1486 (Simoniti, *Santonino* 1991, 39).

The data on the Bronze Age hilltop enclosure and on the Early Medieval activities are convincing. The likely location of the cemetery needs further research. The exceptional religious significance of the area until present days (Kravanja 2007) could be used to support the hypothesis (cf. Pearson 1999, 21–44; Insoll 2004, 123–131; Lane 2008).

Location: In the shadow of the northeastern-most exposure of the Mija Mountain the site is overlooking parts of the Nadiža and Idrija valley. See also **9**. At the time of this research the site and its surroundings were covered in dense vegetation, predominantly young broadleaf forest.

Communications: The cliffs are limited to the northern and eastern side of the hill, while the slopes on the southern and western side are steep. The only access to the hilltop is from the southern side. See also **5**.

The location affords an excellent overview of sites around Robič and Staro selo (**7–11**) as well as the best arable land in the Idrija valley and Gradič (**13**) in the background.

Previous research: Apart from the slight revisions by N. Osmuk (Osmuk 1997, 9) no research had surpassed the topographic data provided by C. Marchesetti until the recovery of the early medieval

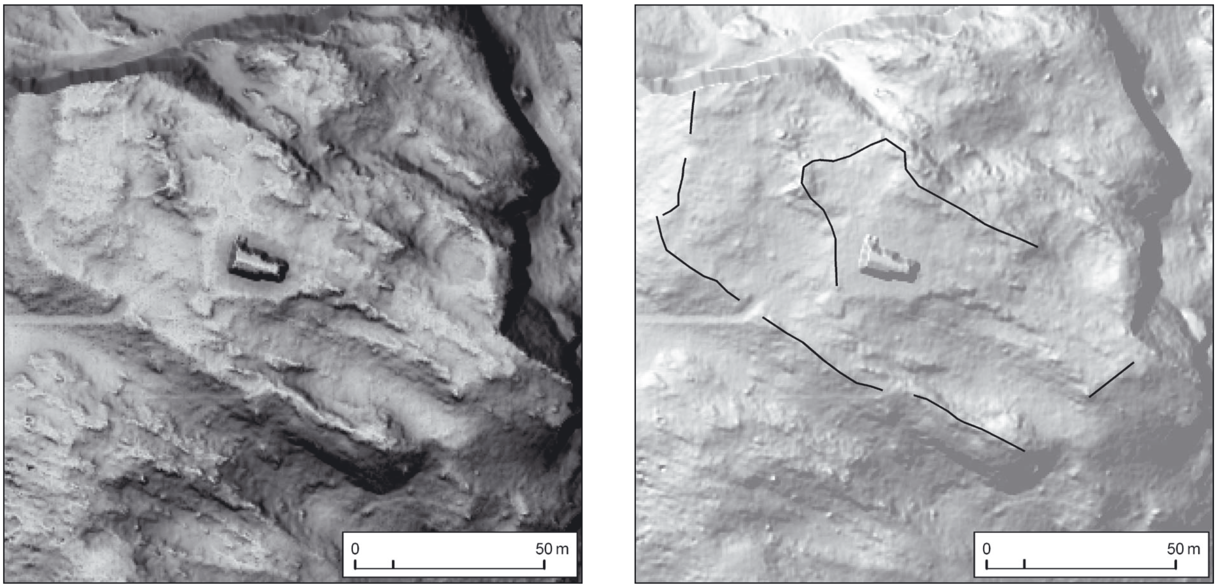


Fig. 6: Sv. Volar (cat. no. 6), lidar-derived DEM and the plan of the archaeological features.
Sl. 6: Sv. Volar (kat. št. 6), DMR izdelan iz lidarskih podatkov in načrt arheoloških struktur.

finds (Knavs, Mlinar 2000–2004). The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Prehistoric earthworks, especially ramparts.

Archaeological interpretation of lidar-derived data (*fig. 6*): On the eastern and southern side poorly preserved ramparts have been recorded in the length of 126 m (0.1 to 0.7 m high, 2.5 to 3.3 m wide). Most likely, the poorly preserved 15 m long earthwork on the eastern side is a remnant of ramparts as well. The central plateau – nowadays with a medieval church in the middle – is 0.9 to 1.5 m raised above the rest of the site. This plateau as well as the mound-like feature on the eastern edge of the site is of natural origin, although man-made alterations are not excluded. The area of the central plateau is 1712 m^2 and of the lower plateau 2568 m^2, 4280 m^2 combined. Both are flat with slopes of less than 10 degrees on 43% of the area.

The site is entirely enclosed, either by ramparts or cliffs. The preserved ramparts are considerably lower than those on the known Iron Age hilltop enclosure (**13**). The internal division – being of natural or man-made origin – is in line with expectations for a hillfort. Lidar-derived data therefore provide additional arguments in support of the Bronze Age hilltop enclosure interpretation.

During the ground-truthing (B. Štular and E. Lozić, 19.–22.1. 2011) no artifacts were recorded but the ramparts have been recognized.

7

Name: **Lašče** near **Kred** (EŠD 15333)

Description: The local tradition of Roman period finds has been recorded (*RNKD*, EŠD 15333).

The location needs further research to be confirmed as an archaeological site. The possible displacement of local tradition – the confirmed site with a similar place name V laščah (**11**) is situated less than 3 km to the east – should be considered.

Location: On the left bank of the Nadiža River in one of the widest parts – circa 600 m – of the valley and just east of the Nadiža – Soča watershed divide. At the time of this research the northern half of the location was being used as a meadow while the southern half was covered in dense young broadleaf forest.

Communications: Not directly adjacent but in the proximity of the ancient routes hub. See **5**.

The surrounding sites (**6, 8–10**) are all visible.

Previous research: Archaeological topography by N. Osmuk has not been followed up.

Potential features in lidar-derived data: Earthworks and path network hub.

Archaeological interpretation of lidar-derived data (*fig. 7*): No man-made features have been recorded. At least half of the area is located on unstable Nadiža gravel sediments, i.e. within the active floodplain. Traces of any permanent structures – as unlikely as it is for them to have been built there in the first place – would have been obliterated in a short period of time (cf. Brown 1997, 91–96; Mlekuž 2009).

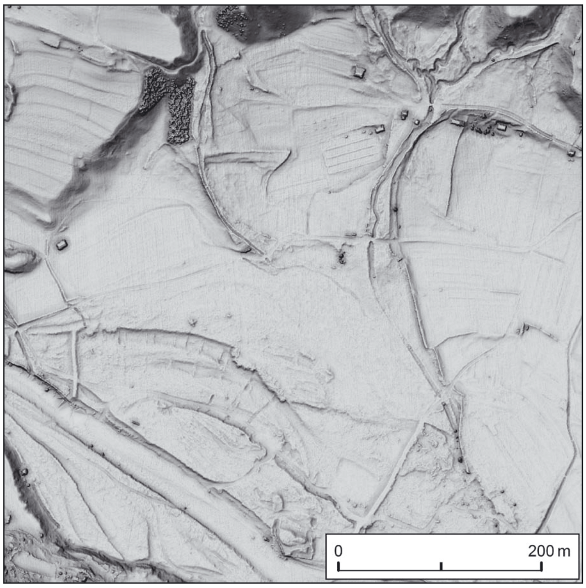


Fig. 7: Kred (cat. no. 7), lidar-derived DEM. The remnants of vegetation in the upper left corner could not be removed from the DEM.
Sl. 7: Kred (kat. št. 7), DMR izdelan iz lidarskih podatkov. Ostankov vegetacije v zgornjem levem kotu ni bilo možno odstraniti iz DMR-ja.

During the ground-truthing (B. Štular and E. Lozić 24.1. 2011) no additional data were recorded.

8

Name: **Der** near **Kred** (ID 010610.02)

Description: C. Marchesetti mentions the prehistoric hillfort on the Der hill. The WWI activities, concentrating on this hill as a showcase for the Italian army's strength, presumably destroyed all traces of prehistoric earthworks.

Although Marchesetti's reports are considered reliable (cf. **4**), the absence of any subsequent finds recovered from illegal metal detecting – treasure hunters are roaming the site in search for WWI remains – or even local tradition (cf. **9**) raises doubts about the existence of a hilltop enclosure.

Location: A small hill, rising 44 m above the valley floor, has steep slopes but is unapproachable only from the southern side. It is situated on the southern edge of the Idrija valley, exactly on the Nadiža-Soča watershed divide. The location on the shady side of the valley, squeezed between the steep slopes of Matajur Mountain and wetland (Štular 2010, 90–93), is unfavorable for agriculture. At the time of this research the site and its surroundings were in dense vegetation, predominantly young broadleaf forest.

Communications: See **5**.

All surrounding sites (**5–7, 9–11, 13, 18**) are visible from the Der hill summit.

Previous research: Topographic observations by Marchesetti (Marchesetti 1893a, 319; Marchesetti 1903, 89) could not be verified (Vuga 1974b) and no additional discoveries have been reported. The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Earthworks belonging to WWI remains; possible remnants of prehistoric earthworks and/or signs of their removal.

Archaeological interpretation of lidar-derived data (*fig. 8*): The Der hill is elongated and is gradually sloping from the summit on the western side towards the east. It has no recognizable plateau. 55% of the 18139 m^2 hilltop has slopes above 25 degrees and only 11% less than 10. Ample WWI remains have been documented but these are mostly confined to the southern side sheltered from the enemy's view, to the slopes and to the underground tunnels. The hilltop itself has few WWI remains. The only flat area is a small (328 m^2) plateau. Although it was extensively reworked during WWI there are no signs of extensive areas of removed, reworked or otherwise damaged previous earthworks, such as on Gradič (**13**) and Grad (**16**).

The Der hill exhibits neither man-made earthworks (of pre-WWI date) nor morphology suitable for a hilltop enclosure. Had there been a hilltop enclosure similar to others in the area, considerable man-made alterations would be necessary and these would have left traces regardless of the WWI fortifications.

During the ground-truthing (B. Štular and E. Lozić 19.–22.1. 2011) no additional data were recorded.

9

Name: **Molida** near **Kred** (ID 010610.03; EŠD 5030)

Description: "Roman house- and road pavement as well as finds" were reported in the 1890s, a Valentinianus III (425–455) gold coin among the finds. Also, recollections of supposedly Roman period findings during the WWI railway building have been recorded among the inhabitants of the present day Robič hamlet (Osmuk 1985c; Župančič 1991; Kos, Šemrov 1995, 18).

The reports – in part contradictory to each other – are based either on interviews with eyewitnesses or rumors, e.g. reported by the local bartender. All finds have been lost and the exact locations are ambiguous. The dating of the building remains anything but certain. The only strong evidence is

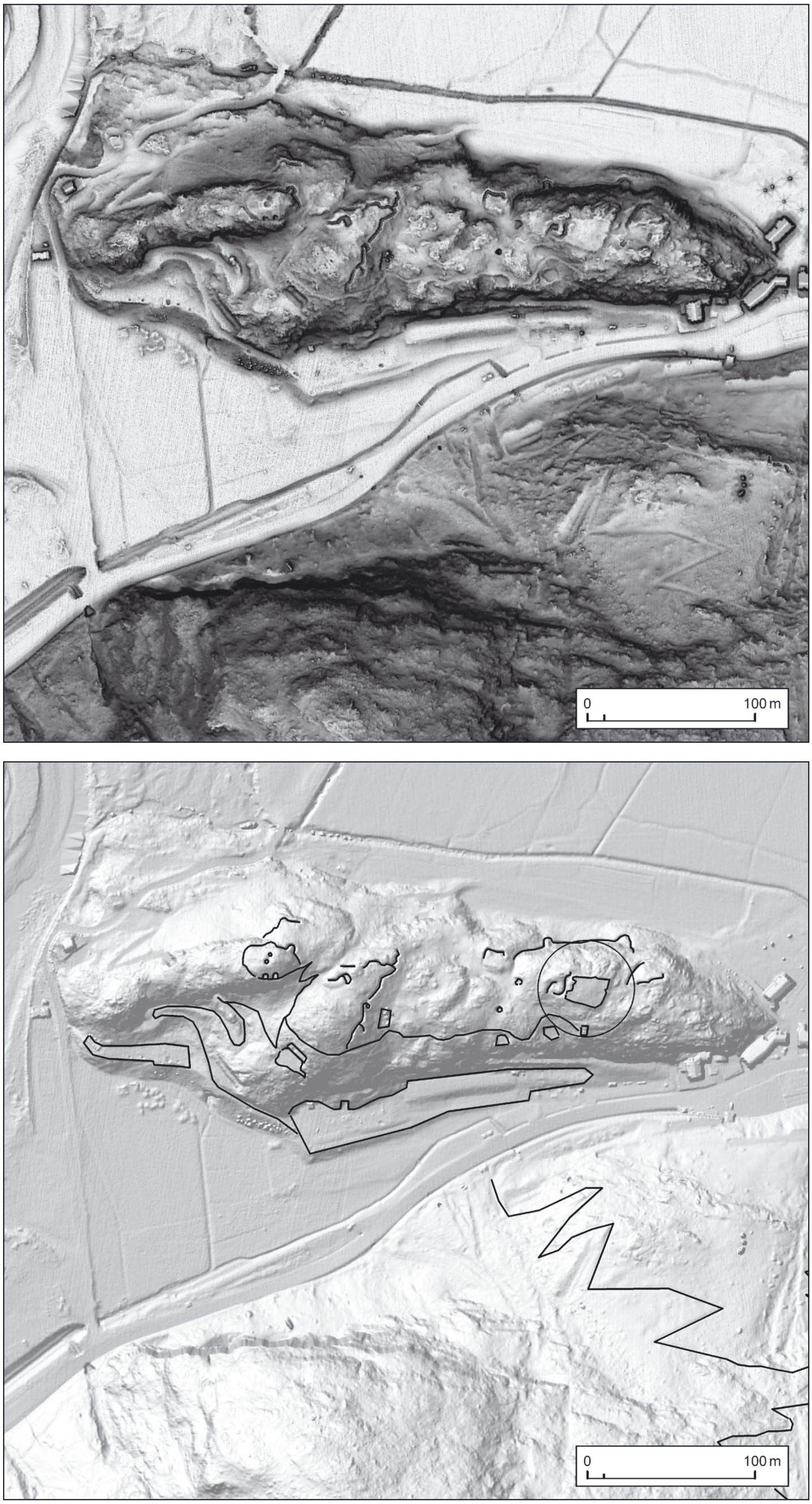


Fig. 8: Der (cat. no. 8), lidar-derived DEM and the plan of WWI features.
Sl. 8: Der (kat. št. 8), DMR izdelan iz lidarskih podatkov in načrt ostankov iz prve svetovne vojne.

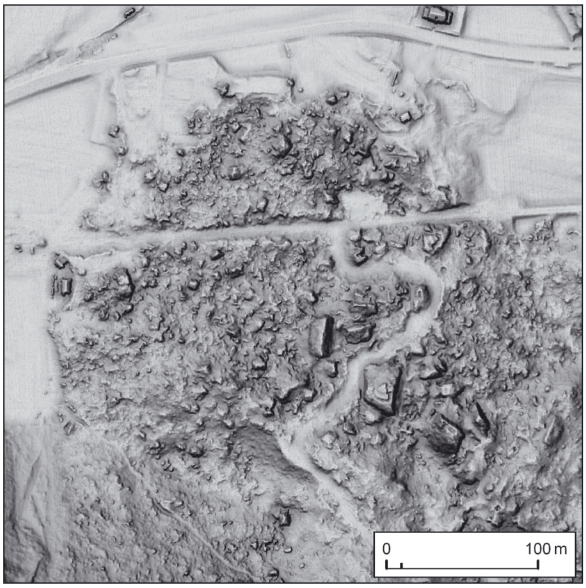


Fig. 9: Molida (cat. no. 9), lidar-derived DEM. Ample WWI remains that are visible are dealt with below (cat. no. 26).
Sl. 9: Molida (kat. št. 9), DMR izdelan iz lidarskih podatkov. Vidni so številni ostanki iz prve svetovne vojne, ki so obravnavani v nadaljevanju (kat. št. 26).

the attribution of the golden coin, but the exact location of this find is unknown. The oral tradition on buried village, sometimes invoked to underpin archaeological finds, is in fact an example of cosmogonical myth about the origins of new settlements and communities, i.e. the tale of the vanished lake (cf. Hrovatin 2007; Kravanja 2007). As such, it is not based on possible archaeological finds but rather on the geographical and geomorphological setting (cf. **6** as a contrary example). Therefore there is no solid evidence of any archaeological remains in this site, and only new data can confirm or refute the existence of an archaeological site.

Location: See **8**. At the time of this research the site and its surroundings were covered in dense vegetation, predominantly young broadleaf forest.

Communications: See **5**.

The neighboring sites (**7, 8, 10**) are visible.

Previous research: Finds and findings were reported between the years 1886 and 1899 by acknowledged scientists of the time, O. Gumprecht, C. Marchesetti, L. K. Moser and S. Rutar (overview in Župančič 1991, 166–167). N. Osmuk gathered additional local traditions of presumed finds since WWI (Osmuk 1985c). In the last century, archaeologists were not able to confirm the initial reports.

Potential features in lidar-derived data: Possible building remains on the edges of the (now removed) railway tracks.

Archaeological interpretation of lidar-derived data (*fig. 9*): The Molida area, poorly defined to start with, can be described as either covered in avalanche debris or else heavily altered: post-medieval land improvement followed by intensive WWI use as a military railway station has been followed by returning the area to agricultural use. Therefore, no additional features predating the described processes have been recorded.

During the ground-truthing (B. Štular and E. Lozić 19.–22.1. 2011) no additional data were recorded.

10

Name: **Na gomili** near **Staro Selo** (ID 010620.02; EŠD 15359)

Description: A prehistoric burial mound was reported in 1889, but the site has never been confirmed beyond D. Vuga's discovery of a mound (Vuga 1979).

The assumed Copper Age settlement (ID 010620.01) is no longer considered a potential site (Osmuk 1997, 9).

The location needs further research to be confirmed as an archaeological site. The possibility of the displacement of local tradition should be considered.

Location: On the western side of the present day village of Staro Selo. See **11**. At the time of this research the site was being used as a meadow.

Communications: See **11**.

The neighboring sites (**6, 8, 9**) are visible.

Previous research: The 1889 source has been lost (*ARKAS*). No follow up research beyond the 1970s topography (Vuga 1979).

Potential features in lidar-derived data: Mound.

Archaeological interpretation of lidar-derived data (*fig. 10*): No mound-like features at the described location have survived to the present day. However, 500 m west from the village (center at G-K coordinates x – 5386510, y – 5123675) five mounds have been recorded on lidar data, 16 to 20 m in diameter and 0.7 to 5 m high. Additionally, several round features with a diameter of 3 to 14 m are discernable as crop marks on various vertical aerial and satellite photographs (RS 2007; vertical photographs acquired at the same time as the lidar data; Google Earth's imagery from 2007 available in 2008 but now replaced), but these seem more likely to be caused by factors other than sub-soil feature remains. Since all of the described features have been incorporated into the existing field boundaries, it is impossible to discern whether these are natural or man-made features. During the ground-truthing (B. Štular and

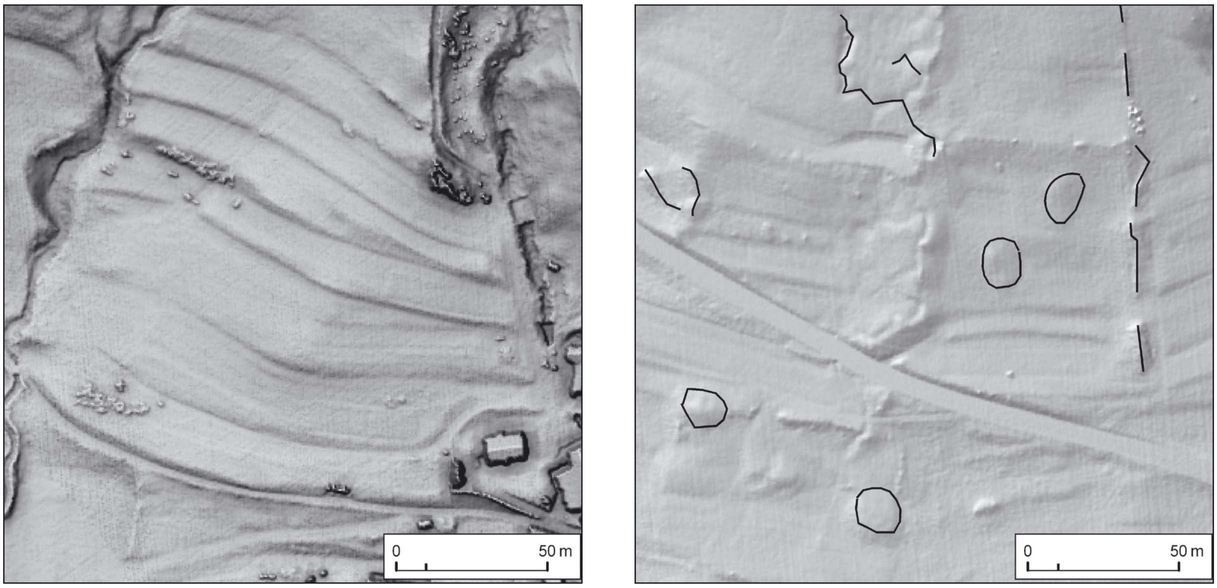


Fig. 10: Na gomili (cat. no. 10), lidar-derived DEM and the plan of the archaeological features recorded 500 metres west of the supposed site.
Sl. 10: Na gomili (kat. št. 10), DMR izdelan iz lidarskih podatkov in načrt arheoloških struktur, dokumentiranih 500 m zahodno od domnevne lokacije gomile.

E. Lozić, 19.–22.1.2011) no artifacts were recorded, but the mounds have been recognized.

Only archaeological excavation can provide an interpretation of the recorded mounds, but it is highly likely that these are the mounds reported in 1889.

11

Name: **V laščah** near **Staro Selo** (ID 010620.03/04/05; EŠD 5043)

Description: Roman period finds and a road were reported in the 1890s. A settlement is indicated by the finds of coins and building material. Large stone mounds integrated into the present field boundaries are considered to be the remnants of the buildings (Osmuk 1985d; Osmuk 1997, 10–11). Some of the walls discovered in the 1970s and 1990s on the western fringes of the present day village might also belong to the Roman period settlement (Osmuk 1999d).

The evidence for a Roman period activity area is convincing. It should be mentioned that the place name V laščah is indicative of Late Roman settlements (cf. Truhlar 1979; Truhlar 1983). The dating of the findings within the modern village and of the road has not been confirmed by archaeologists and remains ambiguous.

Location: On the north of the Idrija valley, impressed in the slopes of the Kobariški Stol mountain to maximize the exposure to the sun and to avoid the flood risk at the same time. At the time of this research the site was being used predominantly as a meadow; the potential archaeological features are covered in patches of dense young broadleaf forest, i.e. unkempt hedge.

Communications: Adjacent to the stretch of the Friuli plain – Carinthia track (see **5**).

The site overlooks the valley with the main communication, alluvial flood plain and the adjacent fertile fields in the foreground and neighboring sites (**6, 8, 9, 13, 18**) in the background.

Previous research: S. Rutar (Rutar 1890) and C. Marchesetti (Marchesetti 1893a, 319) have mentioned the "settlement", coins and "wide paved Roman road" in the 1890s. These finds have been reported as discovered during the road works. N. Osmuk provided the precise location (Osmuk 1985d) and possible additional findings (Osmuk 1999d). No follow up research.

Potential features in lidar-derived data: Earthworks, e.g. buildings.

Archaeological interpretation of lidar-derived data (*fig. 11*): The mounds are clearly visible but do not display any recognizable features. In the central part a man-made square plateau (18.1 by 30.8 m; 200.2 m^2) can be recognized. This feature stands out of the pattern after which the terraces are modelled since it is the only square feature amongst terraced strips. Although incorporated into the agrarian terracing it seems that it had been planned and built for a non-agrarian purpose.

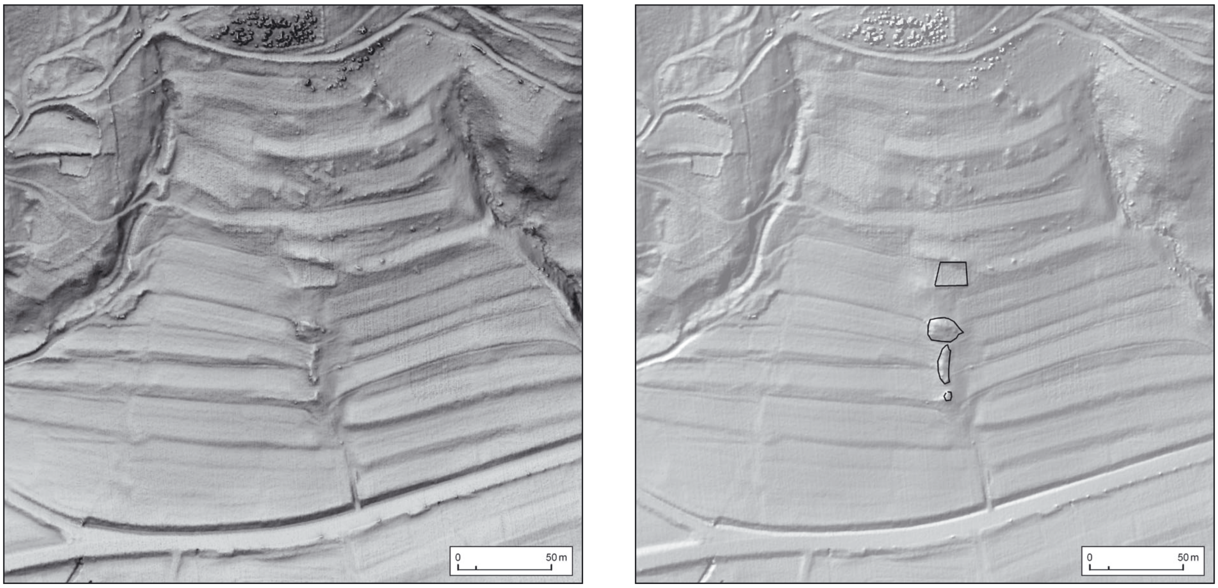


Fig. 11: V laščah (cat. no. 11), lidar-derived DEM and the plan of the archaeological features.
Sl. 11: V laščah (kat. št. 11), DMR izdelan iz lidarskih podatkov in načrt arheoloških struktur.

During the ground-truthing (Z. Modrijan and T. Milavec, 2.6. 2008) no additional data were recovered. During the ground-truthing (B. Štular and E. Lozić, 19.–22.1. 2011) several large shards of Roman brick were recorded exclusively in the area of the above-described features.

The lidar-derived data and ground-truthing both support the evidence of the Roman period intensive – beyond mere agricultural – use of this area.

12

Name: **Tonovcov grad** near **Kobarid** (ID 010609.01/02/03/04; EŠD 5022)

Description: The fortified settlement of Tonovcov grad represents one of the largest and most important Late Antiquity period settlements in the southeastern Alps. Although the artifacts date as far back as the late Stone Age period and a substantial quantity of metal finds is attributed to the Hallstatt and La Tène periods, the best-preserved finds and findings date to the end of the 5th and 6th century. Extensive architectural remains from this time reveal houses, churches and a defensive wall protecting the more exposed parts of the settlement. Dwelling houses were concentrated in a small depression affording some protection from the natural elements, while the early Christian churches were situated on a small plateau above with a commanding view of the settlement (Ciglenečki, Modrijan, Milavec 2011).

The evidence gathered in several excavation campaigns is overwhelming.

Location: On a small hilltop surrounded by cliffs and very steep slopes. The top plateau is sloping towards the southwest and has been terraced. Nowadays the site and the surroundings are covered in dense vegetation, mostly young broadleaf forest.

Communications: The only possible access to the summit is from the northeast from the adjacent contemporary track (see **5**).

Situated in the shadow of surrounding mountains, the site is overlooking the Soča gorge on the eastern side and a narrow side valley on the west with a limited view of the Soča valley towards the south. The view over both modern and late medieval roads connecting Kobarid and Bovec (Štular 2011a, fig. 1.41) is limited to the overlook over the stretch of the track adjacent to the site. Veliki gradec (**15**) is entirely visible, as are parts of Gradič (**13**) and some find-spots (**22, 23**).

Previous research: The site has been known since the late 19th century and has been systematically researched since the 1990s (see Ciglenečki, Modrijan, Milavec 2011 for an overview). The majority of the site, however, remains unexcavated.

Potential features in lidar-derived data: Buildings, walls, ramparts.

Archaeological interpretation of lidar-derived data (*fig. 12*): After initial analysis of lidar-derived data new features have been recorded in eight out

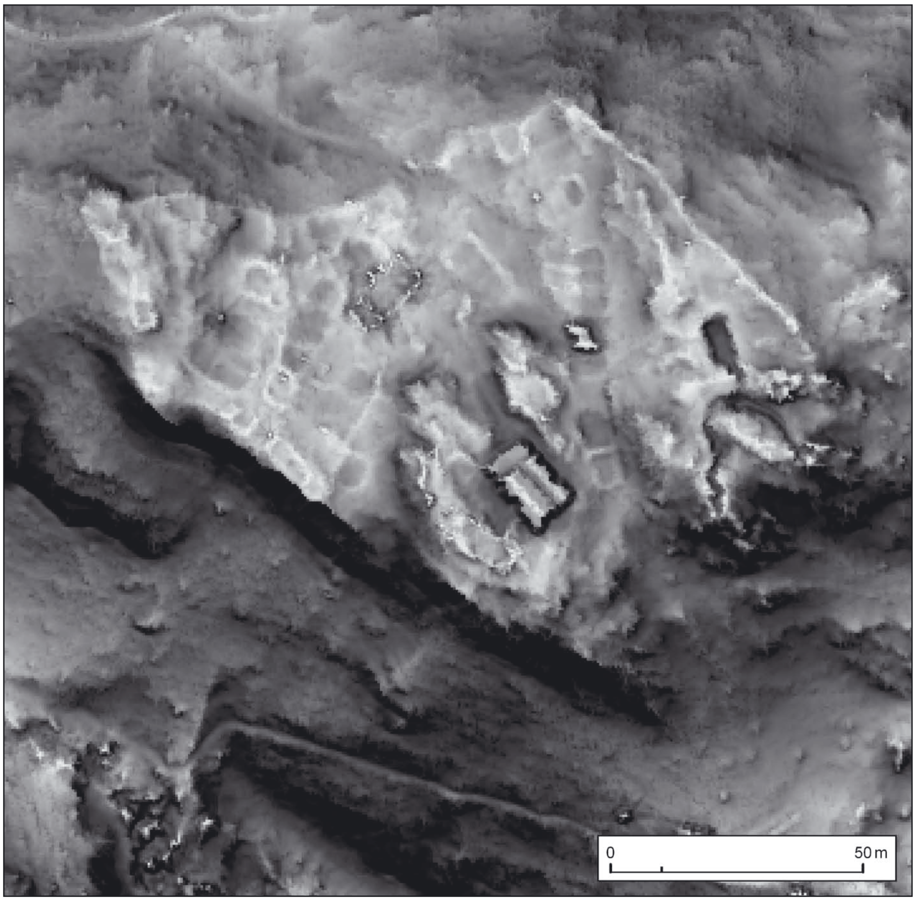
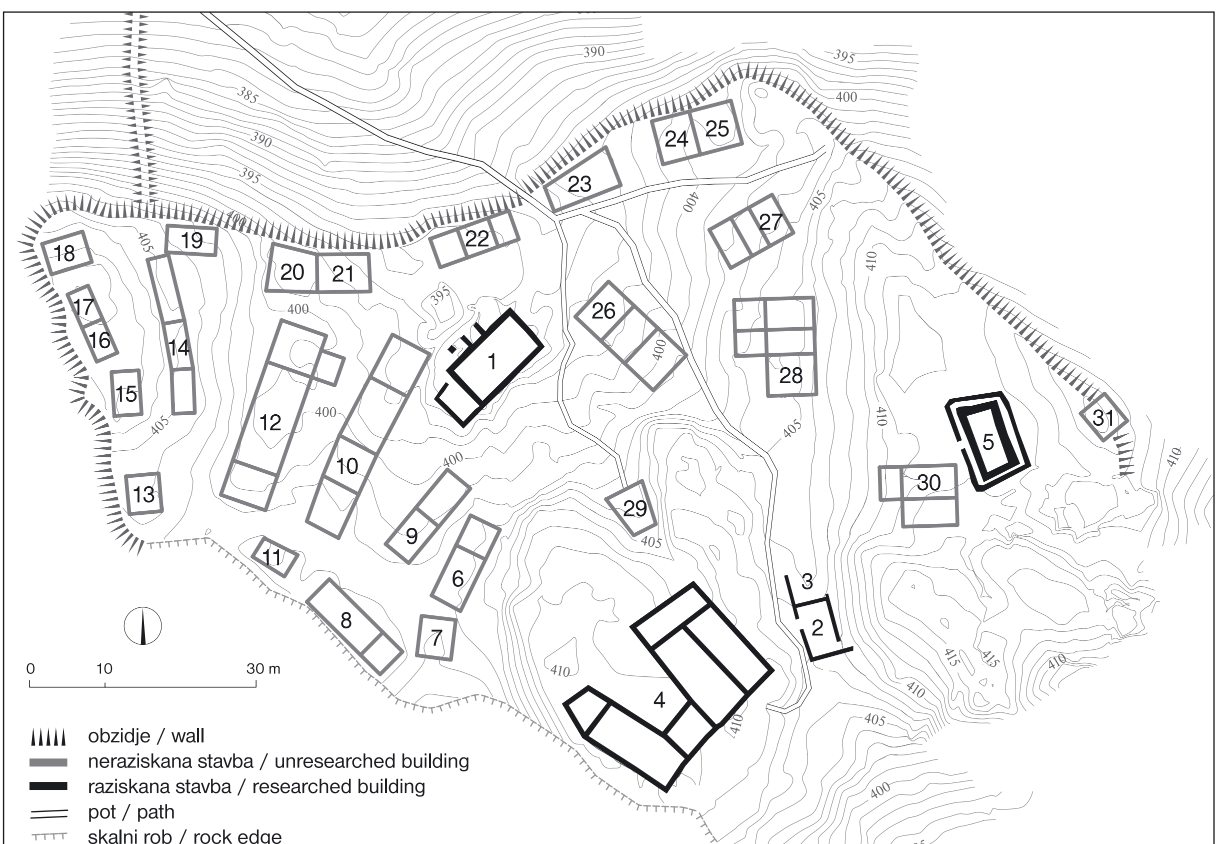


Fig. 12: Tonovcov grad (cat. no. 12), lidar-derived DEM and the plan of the archaeological features (Ciglenečki, Modrijan, Milavec 2011, fig. 1.7).
Sl. 12: Tonovcov grad (kat. št. 12), DMR izdelan iz lidarskih podatkov in načrt arheoloških struktur (Ciglenečki, Modrijan, Milavec 2011, sl. 1.7).



of nineteen previously recognized but unexcavated buildings. Also, two small buildings incorporated into ramparts – possible watchtowers – have been recognized (Kokalj, Zakšek, Oštir 2011, 271). Afterwards one more building has been detected (Ciglenečki, Modrijan, Milavec 2011, fig. 1.7).

In spite of extensive previous research, important additional information has been extracted from lidar-derived data.

13

Name: **Gradič** near **Kobarid** (ID 010609.07/08/09/10; EŠD 226)

Description: This site incorporates an Iron Age (Hallstatt and La Tène period) hilltop enclosure, a late prehistoric period cult area, and a Roman period settlement.

The Iron Age hilltop enclosure has been badly damaged by the monument built to commemorate the Italian soldiers who perished in the WWI. The enclosure is dated to the Iron age indirectly via the cemetery (**14**) undoubtedly belonging to this settlement (Gabrovec 1987; Osmuk 1997, 9–10; Mlinar, Pettarin 2007). The cult area is located on the western fringe of the prehistoric enclosure. It has been interpreted as such based on the finds: a large quantity of late Iron age jewelry, ceramic drinking vessels and juvenile sheep/goat bones cut into small pieces, and above all, the 28 miniature bronze statuettes. Also among the finds are 30 silver pieces that date this activity into the 1st c. BC (Osmuk 1997, 15–16; Osmuk 1998). Parts of the Roman period settlement have been destroyed on the southwestern slopes of the Gradič hill, but an archaeologist was able to examine the site afterwards (Osmuk 1982). The settlement is dated indirectly in the Roman period by the artifacts excavated in disturbed contexts on the cult area, 1st to 4th c. AD *amphorae* and 4th to mid 5th c. AD metal artifacts (Osmuk 1984; Ciglenečki 1997, 26; Maggi, Žbona-Trkman 2007, 68).

There seems to be some confusion regarding this site complex, so it is worth repeating the known facts: the evidence on the location of a prehistoric hilltop enclosure is solid but there is no direct evidence to date it; the location, interpretation and dating of the cult area are asserted; however, the location and dating of the Roman period settlement are lacking any direct evidence.

Location: The Gradič hill is the easternmost edge of the Kobariški Stol Mountain. Although rising 68 m above the Idrija River terrace – i.e. the Kobarid plain – and 111 m above the Soča River, the hilltop is overshadowed near other Stol Mountain summits in the northwestern direction and near Krn Mountain in the east. At the time of this research the site had either been built over or covered in dense vegetation, predominantly young broadleaf forest.

Communications: Only a cliff on the eastern side is unapproachable, steep slopes on the southern side can be negotiated via a short diversion towards the west. The summit is easily approachable from the north and west.

The site is overlooking the Idrija – Soča confluence and river crossing, but is overlooked by the higher hills located west of the site. From the western ramparts it has a partial overview of the sites in the Idrija valley (**6, 8, 9, 11, 18**). The view towards the north is limited but the Tonovcov grad site (**12**) is just visible. Also visible are the neighboring find-spots (**20, 22, 23**). The contemporary cemetery (**14**) is not visible from the existing parts of the enclosure but must have been visible from the southern ramparts before they were destroyed.

Previous research: S. Rutar (Rutar 1882) mentioned the hillfort settlement and "the Roman road" leading from it towards the north (**12**). The site never received as much attention as the cemetery (**14**), and the area within the earthworks has never been researched. Unfortunately the area not destroyed by the WWI monument has been ransacked by 30 years of illegal metal detecting (Osmuk 1977) that has not stopped to this day. Excavations following the damaging interventions on the slopes have been carried out just west of the ramparts (Osmuk 1984; Osmuk 1997, 15–16).

Potential features in lidar-derived data: earthworks, e.g. prehistoric ramparts and/or signs of removal, terracing.

Archaeological interpretation of lidar-derived data (*fig. 13*): A large number of features have been recorded on this site complex. The features can be grouped into field boundaries (relict, historic, and modern), modern built area (road, WWI monument), paths (unknown age), and archaeological features predating the post-medieval period.

Field boundaries, apart from the most recent ones, are most often stone built walls. These encircle the prehistoric enclosure but most notably enclose the cult area and terrace with a possible Roman period settlement. Thus the stratigraphic record of the cult area can be explained since the archaeological trench was dug in the midst of an abandoned field. Also, the reported Roman period building remains are even more ambiguous.

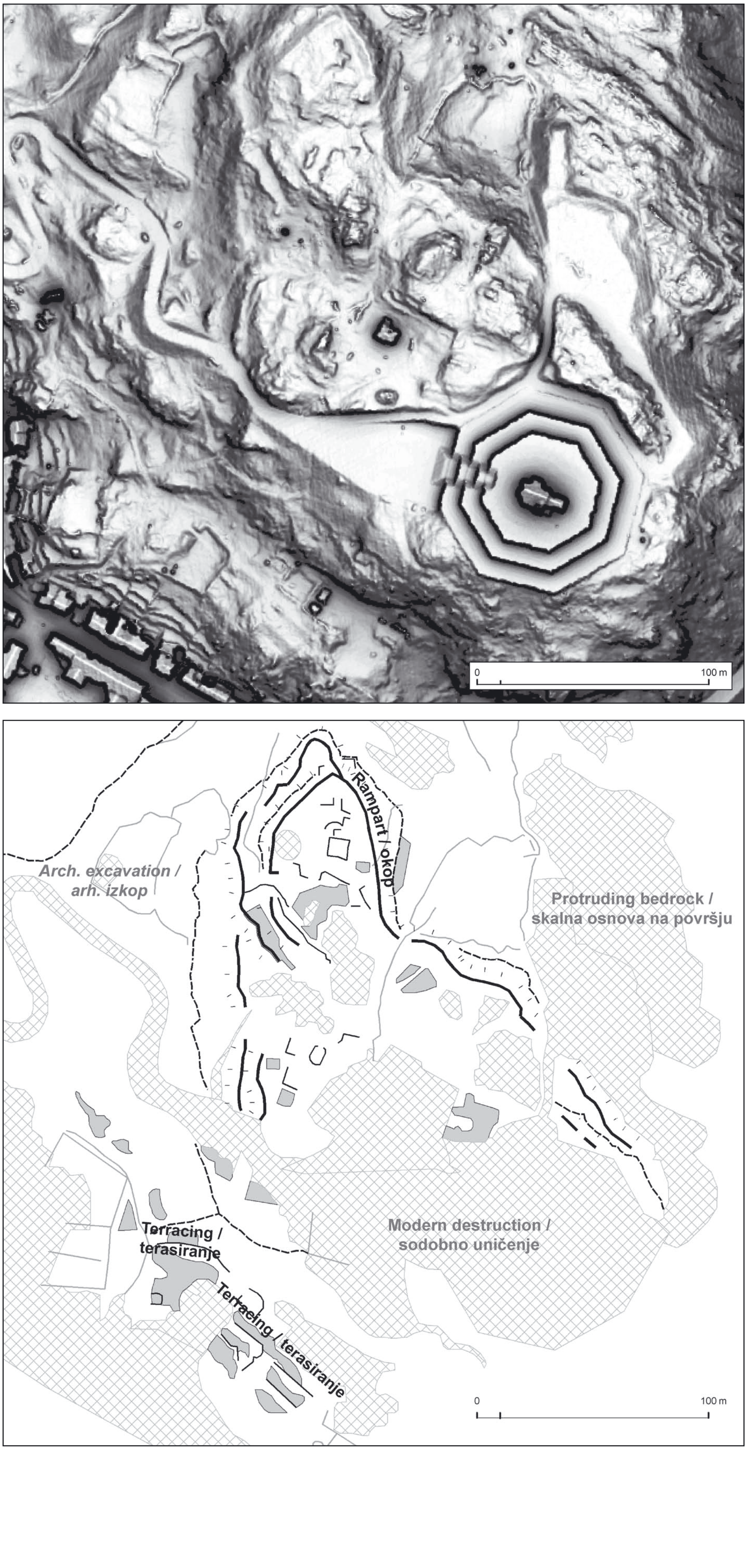


Fig. 13: Gradič (cat. no. 13), lidar-derived DEM (visualized with the Uniform sky model by P. J. Kennelly and J. A. Stewart) and the plan of the archaeological features.
Sl. 13: Gradič (kat. št. 13), DMR izdelan iz lidarskih podatkov (vizualizacija s t. i. modelom enotnega neba, avtorja P. J. Kennelly in J. A. Stewart) in načrt arheoloških struktur.

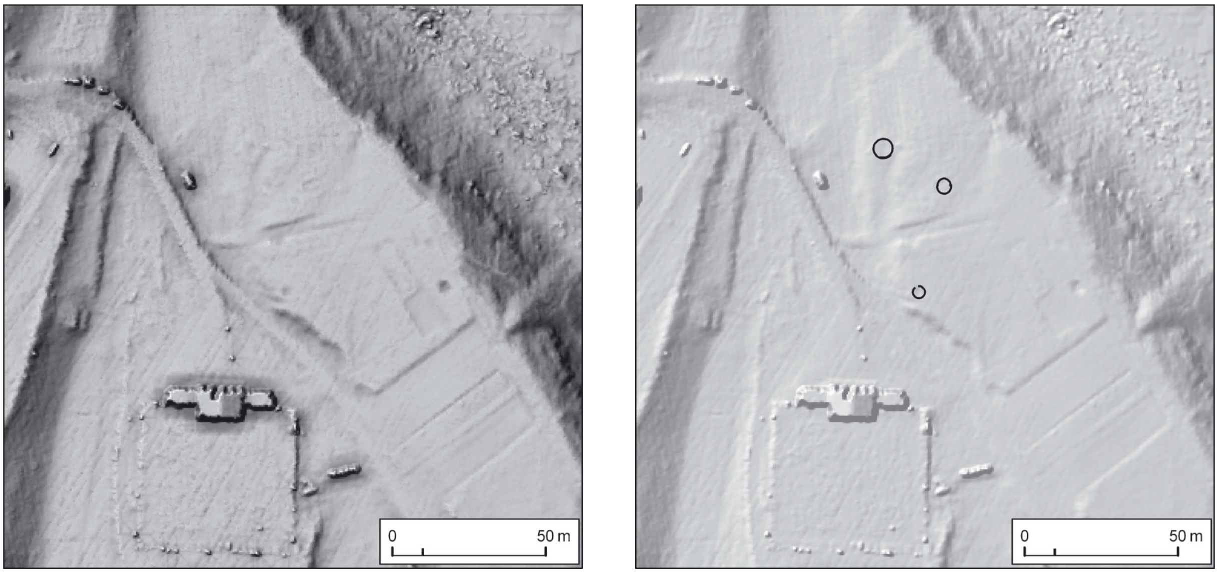


Fig. 14: Mlekarna Planika (cat. no. 14), lidar-derived DEM and the plan of the features (WWI bomb crater and modern earthworks).
Sl. 14: Mlekarna Planika (kat. št. 14), DMR izdelan iz lidarskih podatkov in načrt struktur (bombni krater in moderna zemeljska dela).

The modern built area has – as often noted – destroyed a portion of the prehistoric enclosure (25751 m^2). The WWI monument and road building destroyed 32% of the enclosure area, and the building of a house and its levelled yard has damaged an additional 5%. The remaining 63% of the enclosure remained intact only to be robbed out by illegal metal detecting.

Several paths have been documented ranging from modern hiker's and tourist's paths to paths leading towards now abandoned fields. The existence of paths contemporary to the enclosure has long been known and with an analysis of lidar-derived data we were able to detect those exact paths (Štular 2011a).

Careful recording of the enclosure exposed an elaborated rampart system including a possible ditch and double rampart with a tunnel entrance on the most exposed western side and an acropolis on the least accessible eastern side. The two sections of the outer western rampart's recorded length are 120.8 and 44.1 m. The possible ditch is 141 m long and up to 11.3 m wide. The preserved depth is up to 0.9 m. The inner western rampart continuing into the northern rampart has been recorded in four sections, 31.5 m, 133.2 m, 72.5 m and 41.7 m long. The acropolis rampart's recorded length is 16.5 m. The latter has been all but obliterated by the WWI monument and we were only able to recognize it as such based on the Napoleonic and Franciscan cadastral maps from the early 19th century. The ramparts are preserved up to 5 m high and up to 10 wide.

The elaborated entrance to the enclosure on the western side is the first hard evidence for the existence of a hillfort rather than just an enclosure. The documented entrance can be described as an entrance with the entrance alley, or perhaps as a tangential entrance (Guštin 1978, 115; Dular, Tecco Hvala 2007, 100–103).

Also of great interest are features within the enclosure that are perpendicular to each other. Given the known data on the site, these could either be the remnants of the presumed (Late) Roman period buildings within the enclosure (Ciglenečki, Modrijan, Milavec 2011, 33–52) or even of 1st c. BC fortifications (cf. Horvat 2010). For an adequate interpretation of these, however, additional ground-truthing is needed.

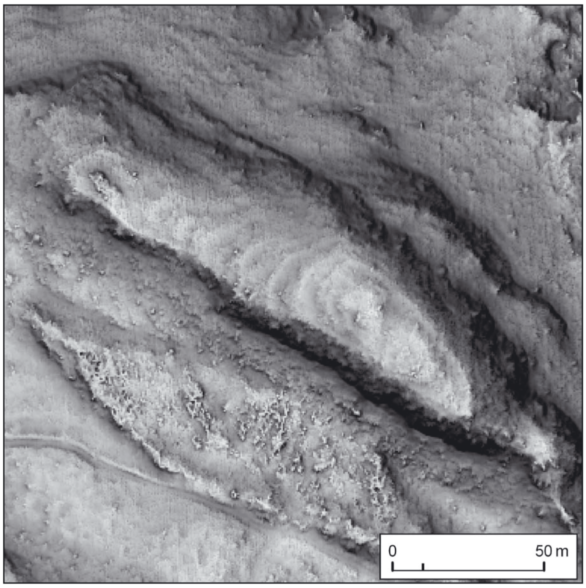
During the ground-truthing (B. Štular and E. Lozić, 19.–22.1. 2011) no artifacts were recorded but the earthworks have been recognized.

14

Name: **Mlekarna Planika** in **Kobarid** (ID 010609.05/06; EŠD 5018)

Description: So far at least 1405 cremated burials have been excavated in this large cemetery, dating to the Hallstatt and La Tène period (Gabrovec 1987; Mlinar and Pettarin 2007, 46–47), with some graves dated to the Roman period (Maggi, Žbona-Trkman 2007, 67 and 72).

Although the site awaits complete archaeological analysis the location and prehistoric date of the



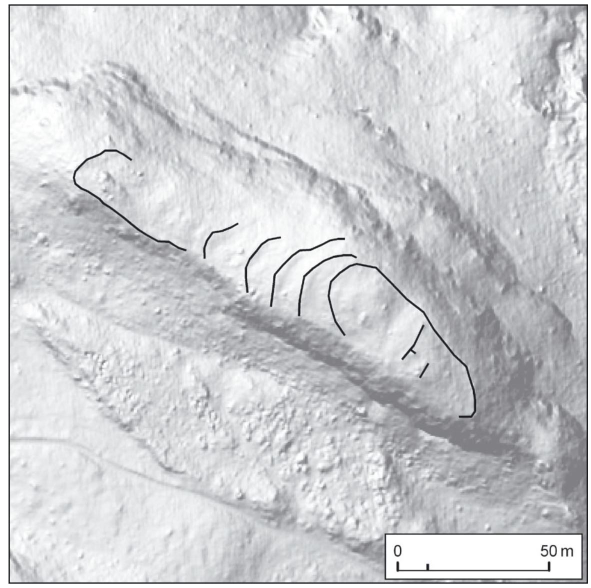


Fig. 15: Veliki gradec (cat. no. 15), lidar-derived DEM and the plan of the archaeological features.
Sl. 15: Veliki gradec (kat. št. 15), DMR izdelan iz lidarskih podatkov in načrt arheoloških struktur.

cemetery are indisputable. The Roman period burials are thus far somewhat scarcely published.

Location: Graves have been documented on the second alluvial Soča river terrace, one and a half kilometre north of the Idrija and Soča river confluence. It is possible that the necropolis extended on the first terrace as well as on the slopes of the adjacent contemporary Gradič hillfort (**13**). At the time of this research the site was partially built up and being partially used as meadows converted from arable fields.

Communications: The location is in direct connection with the Friuli plain – Carinthia communication (see **5**). Locally, the track is adjacent to the Gradič (**13**) and Tonovcov grad (**12**) settlements and seems to be crossing or bypassing the cemetery. The track connecting the contemporary settlement sites of Tolmin and Kobarid was most likely crossing the Soča River just east of the cemetery and joining the main route just west of it (Štular 2011a). The cemetery is therefore situated between the river crossing, the crossroads and the contemporary settlement.

The settlement rises prominently above the cemetery (see **13**) but no other sites are visible.

Previous research: The cemetery was discovered in 1886, and more than 1000 graves were excavated in three campaigns until 1904. Smaller excavations continued in 1955 and in 1979. All but the small 1955 excavations are poorly published (see Duhn, Messerschmid 1939, 109–110 for an overview of older campaigns; Gabrovec 1987, 152–153; Mlinar and Pettarin 2007, 46–47 with bibliography).

Potential features in lidar-derived data: possible features related to the cemetery, e.g. incineration area, path network hub.

Archaeological interpretation of lidar-derived data (*fig. 14*): No additional features have been recorded. The area exhibits prolonged use as arable fields.

During the ground-truthing (B. Štular and E. Lozić, 24.1. 2011) neither additional artifacts nor features were recorded.

15

Name: **Veliki gradec** near **Jezerca** (ID 010607.01; EŠD 5017)

Description: Man-made alterations in the form of a plateau and six to seven terraces with ramparts on the eastern and northwestern side allowed for an interpretation of an undated fortified refuge (Osmuk 1985e; Ciglenečki 1997, 25). Further visits and finds recovered from illegal metal detecting point to a Late Antiquity date (*ARKAS*).

The Late Antiquity period fortified refuge interpretation is highly likely.

Location: A small hill with steep slopes, elongated in the northwest – southeast direction is situated between the Drežnica plateau and the Soča valley. At the time of this research the site and its surroundings were covered in dense vegetation, predominantly young broadleaf forest.

Communications: The easiest access is via the Drežnica plateau – itself hard to reach – since the area is inaccessible from all but the southern side by the deeply cut narrow valley of the Kozjak stream.

The only reasonable approach to the hill itself is in the middle of the southern edge.

Views of parts of Drežnica plateau (**17**) and that of Tonovcov grad (**12**) are possible.

Previous research: No research followed the topography (Osmuk 1985e). The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Earthworks, e.g. ramparts, terraces, possible structures.

Archaeological interpretation of lidar-derived data (*fig. 15*): Lidar-derived data enable an excellent overview of the site. It can be divided into three major parts: the lower plateau, the upper plateau and four terraces overcoming the 25 m of height difference between the two plateaus. The lower plateau's area is 1418 m^2; the area of terraces is 511 m^2 and of the upper plateau 1118 m^2, 3047 m^2 all together. This is roughly one third of the size of the confirmed contemporary settlement (**12**). The slope gradient throughout this site is equally distributed and similar to that of Tonovcov grad (**12**).

The lower plateau – rising 10 to 12 m above the southern approach area – is partially enclosed by 69.7 m long ramparts with the preserved height up to 0.2 m and width up to 1.8 m. The most likely entrance can be recognized in the gap between this rampart and the lowest terrace.

During the ground-truthing (B. Štular and E. Lozić, 25.1. 2011) no artifacts were recorded but the earthworks have been recognized.

16

Name: **Sv. Jurij** in **Drežnica** (ID 010603.00; EŠD 15326)

Description: This site is the location of a demolished church dedicated to St. George, mentioned in the written sources in 1715. While expanding the modern cemetery towards the west, remnants of walls and inhumation graves were reported (Osmuk 1985e).

The assumption for the location of a medieval cemetery seems probable. The Early Medieval date needs further evidence, although Early Medieval graves have often been found around later churches with this church patron, i.e. Sv. Jurij near Legen (Strmčnik-Gulič 1994), Sv. Jurij in Batuje (Svoljšak, Knific 1976, 60–77), Sv. Jurij in Ptuj (Tomanič Jevremov 1996) and the chapels of Sv. Jurij and Martin on Svete gore (Korošec 1971).

Location: The site is still in use as a cemetery located at the southeastern edge of the village Drežnica, half way between the village and Grad (**17**). The immediate surrounding is either built up

Fig. 16: Sv. Jurij (cat. no. 16), lidar-derived DEM.
Sl. 16: Sv. Jurij (kat. št. 16), DMR izdelan iz lidarskih podatkov.

or used as meadows and fields. Both sites and the present day village are situated on a plateau above the Soča valley and under the Krn Mountain.

Communications: The Drežnica plateau has limited communications apart from the modern road, first built as an Italian supply line in WWI. According to local tradition and recorded place name, the use of the shorter route – in direction similar to the modern road – required the use of ladders. The longer route mapped in the 18^{th} century (Rajšp 1997, section 133; cf. Štular 2010, 88–90) was circling north from Veliki gradec (**15**).

Grad (**17**) is overlooking the site.

Previous research: Topographic research in the late 1990s (Cvitkovič 1999, 20) has not been followed.

Potential features in lidar-derived data: Earthworks outside the modern cemetery.

Archaeological interpretation of lidar-derived data (*fig. 16*): The area has been ploughed, and local farmers would be more likely to spot any possible buried walls than would any remote sensing technique. No additional features have been recorded. During the ground-truthing (B. Štular and E. Lozić, 25.1. 2011) no artifacts or features were recorded.

17

Name: **Grad** in **Drežnica** (EŠD 15327)

Description: The site is conjectured to be a potential medieval castle. The assumption is based on the local tradition and place name (Grad, i.e. castle).

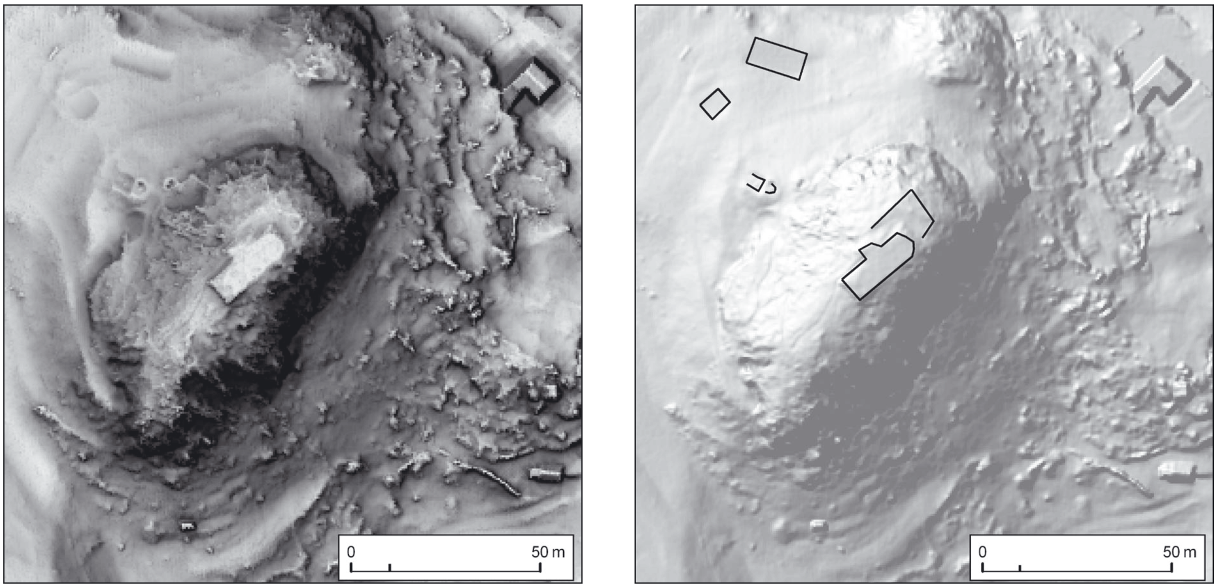


Fig. 17: Drežnica (cat. no. 17), lidar-derived DEM and the plan of the archaeological features. The features in the upper left corner belong to post-medieval outhouses destroyed after the abandonment of arable fields.
Sl. 17: Drežnica (kat. št. 17), DMR izdelan iz lidarskih podatkov in načrt arheoloških struktur. Strukture v zgornjem levem kotu so posrednjeveška gospodarska poslopja, uničena po opustitvi njivskih površin.

The location was heavily altered during and after WWI since the village of Drežnica was the location of the Italian army's headquarters. Therefore, there are no visible remains of the castle.

Location: A small hill in the middle of the Drežnica plateau overlooking the deep-cut Ročica stream on the southeast and the fields and houses belonging to the village on the north and west. At the time of survey the hill was covered in dense vegetation, predominantly broadleaf trees, while surrounded with patches of meadows and broadleaf trees. Also see **16**.

Communications: See **16**.

The site is overlooking the cemetery (**16**), the hamlet of Jezerca situated 1.5 km northwest of the site and the hamlet of Koseč situated 0.8 km to the southeast. Parts of Veliki gradec hill (**15**) are also visible.

Previous research: Topographic research in the late 1990s (Cvitkovič 1999, 20) has not been followed.

Potential features in lidar-derived data: Castle structures, anthropogenic hill alterations.

Archaeological interpretation of lidar-derived data (*fig. 17*): The hilltop – rising 28 m above the surrounding fields – is nowadays dominated by an oblong rectangular platform (8 by 21.4 m; 171.7 m^2) that had been used in WWI, as indicated by iron fittings built into the platform. Beneath that another platform can be recognized: it is 1.6 m lower, and it seems that it was originally of oblong rectangular shape as well (reconstructed rectangle size is 12.8 by 20.7 m; 321.2 m^2). This could be a lower terrace of the WWI construction but could also be the remains of the castle levelled during WWI. The first seems less likely since the approach to this area is partially blocked by the extrusion of the upper WWI platform.

During the ground-truthing (B. Štular and E. Lozić, 25.1. 2011) no artifacts were recorded but the earthworks have been recognized. The WWI platform was built using local stone cut into square blocks in the same way as the nearby outbuilding and the access road built in WWI. However, stones used on this site are up to 50% larger and the possibility that these were reused castle ruins cannot be excluded.

Without archaeological excavation it is not possible either to confirm or to refute the medieval castle existence. The location, place name and the size of the reconstructed platform (e.g. Krahe 2002, 20–22; Gaspari 2008a) allow for the possible existence of a typical small High Medieval castle.

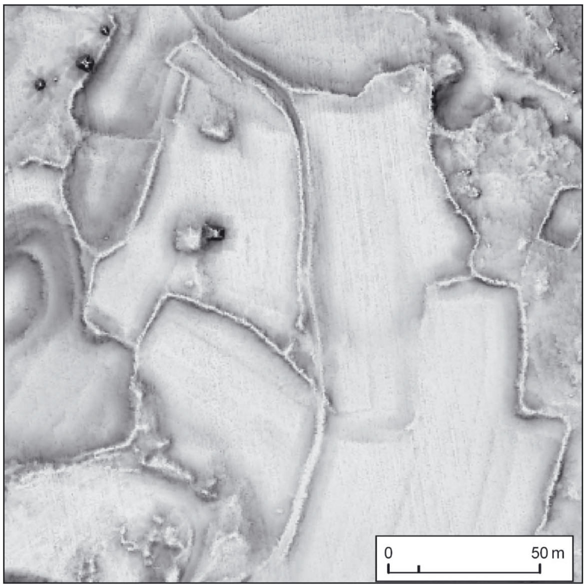


Fig. 18: Kobariško blato (cat. no. 18), lidar-derived DEM.
Sl. 18. Kobariško blato (kat. št. 18), DMR izdelan iz lidarskih podatkov.

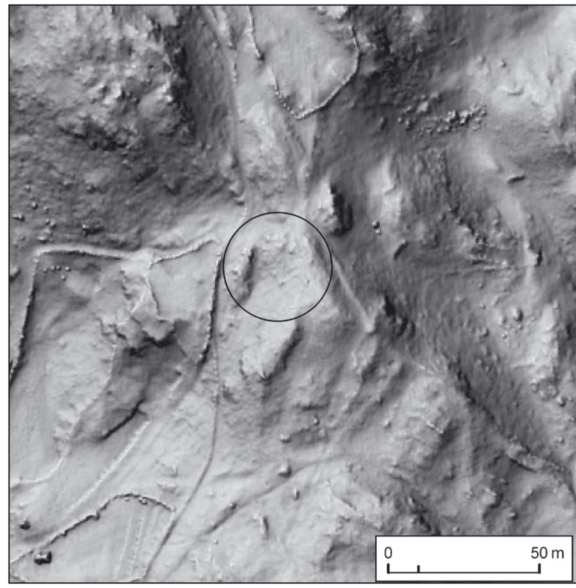


Fig. 19: Skrinjca (cat. no. 19), lidar-derived DEM.
Sl. 19: Skrinjca (kat. št. 19), DMR izdelan iz lidarskih podatkov.

B. Find-spots

18

Name: **Kobariško blato** near **Kobarid** (ID 010609.12)

Description: Metal detecting find-spot of early Roman period jewelry.

The location is ambiguous since it is recorded on the spot where the place name of Kobariško blato is mapped on modern large-scale maps. The place name, as used by local residents, refers to the floodplain between the Kobarid and the recorded location.

Location: A recorded location of the find-spot lies on a low hill above the Kobariško blato floodplain in the Idrija valley. The location affords an overview of the floodplain, Gradič (**13**) and V laščah (**11**) sites. Both the recorded location of the find-spot and the Kobariško blato floodplain were being used as a meadow with patches of broadleaf forest on the slopes at the time of this research.

Communications: Adjacent to the Friuli plain – Carinthia route (see **5**) but located on the other bank of river Idrija that was difficult to cross (cf. Štular 2011a).

Previous research: The find was recovered by the local museum (Zavrtanik 1984). The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Unknown.

Archaeological interpretation of lidar-derived data (*fig. 18*): Both potential areas of the find-spot show intense post-medieval or later land improvement. These would obliterate any earlier earthwork features had there been any.

19

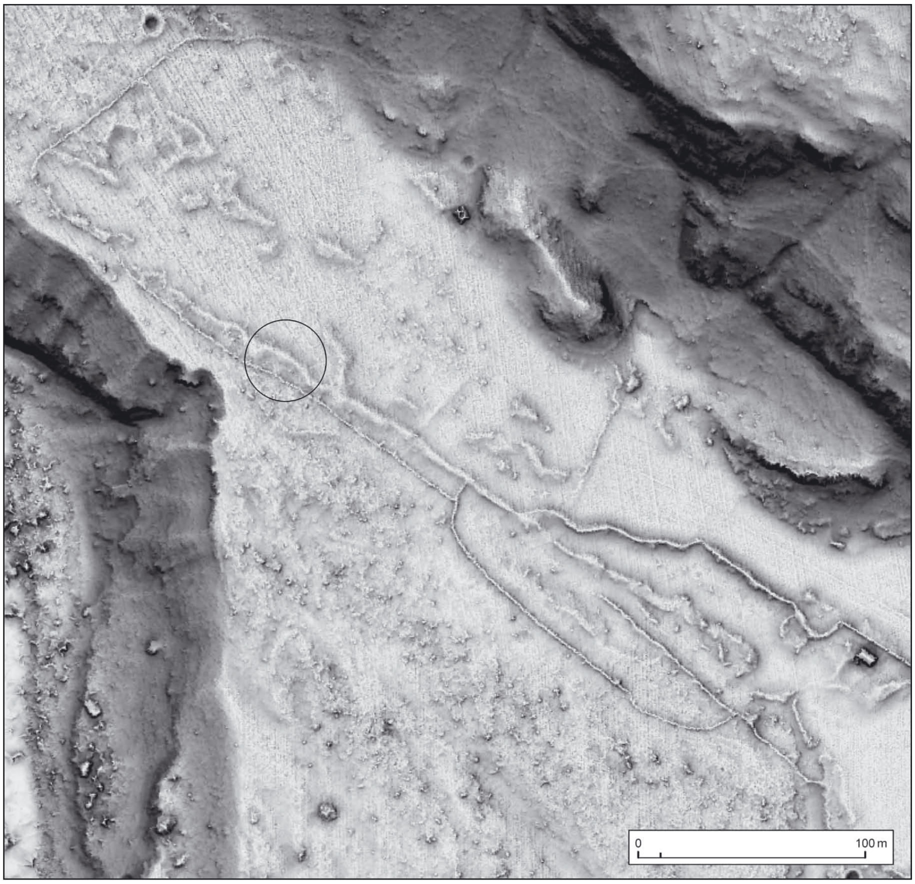
Name: **Skrinjca** near **Kobarid**

Description: In 2004 a hoard of 36 bronze and silver coins was found under an overhanging cliff at a depth of around 40 cm: 34 Roman coins in the hoard were minted before the mid-2nd c. BC and the deposition of the hoard is placed in the second half of the second century BC (Kos, Žbona-Trkman 2009).

The hoard analysis presents overwhelming dating evidence. The exact nature of the finding is not reported – most likely recovered from illegal metal detecting – but the details regarding the location are convincing.

Location: The location of the reported coordinates is 134 m north of the northern tip of the Gradič enclosure (**13**), reportedly some 5 m northwest of the prehistoric path (see **5**).

Communications: Adjacent to the Friuli plain – Carinthia track (see **13**). Despite the proximity the location is not visible from the Gradič ramparts (**13**), even allowing for the earthworks to be 5 m higher above the preserved condition. The location is also



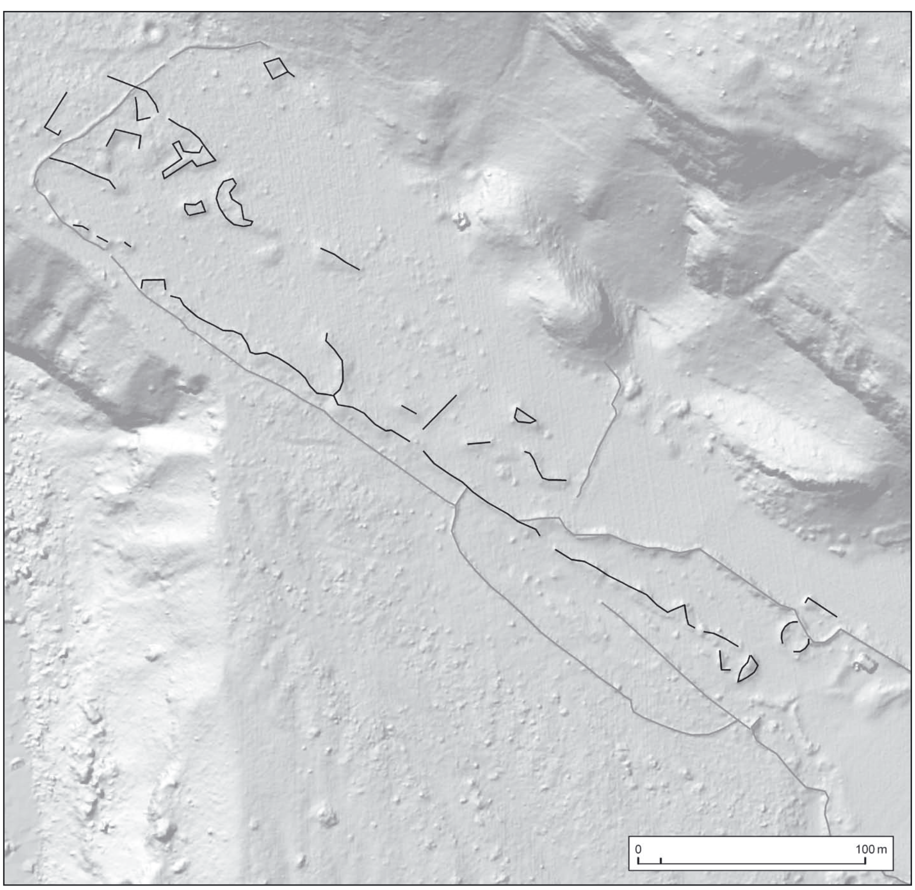


Fig. 20: Jajnkovec (cat. no. 20), lidar-derived DEM and the plan of features. Relict stone built pasture boundaries (grey) are clearly distinguishable from earlier features (black).
Sl. 20: Jajnkovec (kat. št. 20), DMR izdelan iz lidarskih podatkov in načrt struktur. Kamnite ograde opuščenih pašnikov (sivo) se jasno razlikujejo od starejših struktur (črno).

not visible from the presumed contemporary path and from the contemporary cult area (**13**).

Previous research: The find was recovered by the local museum. The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Unknown.

Archaeological interpretation of lidar-derived data (*fig. 19*): The lidar data enabled the above precise description of the location. Other than that, the location is lodged between the post-medieval field boundaries to the east and west. These fields were carefully placed so that every reasonably flat area has been used. Any possible earlier man-made structures would most likely target the same areas and would therefore have been destroyed, as in case of the Gradič cult area (**13**).

20

Name: **Jajnkovec** near **Magozd** (ID 010616.01)

Description: Metal detecting find-spot of Hallstatt period fibulae. Due to the circumstances – the find recovered from metal detecting – the exact location is not beyond doubt.

Location: A small plain on the Soča's left bank situated between steep slopes of the Morizna Mountain and Soča gorge.

Communications: The only easy access is to continue north along the left bank of the Soča from the spot where the Tolmin – Kobarid ancient track crosses over to the Soča's right bank. Approaches from the east and west are all but impossible due to the mountains and Soča gorge, respectively. Modern hiking paths do lead north and link the site with the Bovec area.

Previous research: The find was recovered by the local museum and attributed to the late Hallstatt period by D. Božič. The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Unknown.

Archaeological interpretation of lidar-derived data (*fig. 20*): The lidar data survey exposed field boundaries that are cutting across earthworks of unknown date. The *terminus ante quem* for younger field boundaries has been established at circa 1775, since some of the pastures had been already reforested in 1822 (Štular 2011b). It seems that the field boundaries are post-medieval and the earlier earthworks had been built as an enclosure at some earlier period. The recorded location places the prehistoric fibulae within these earthworks.

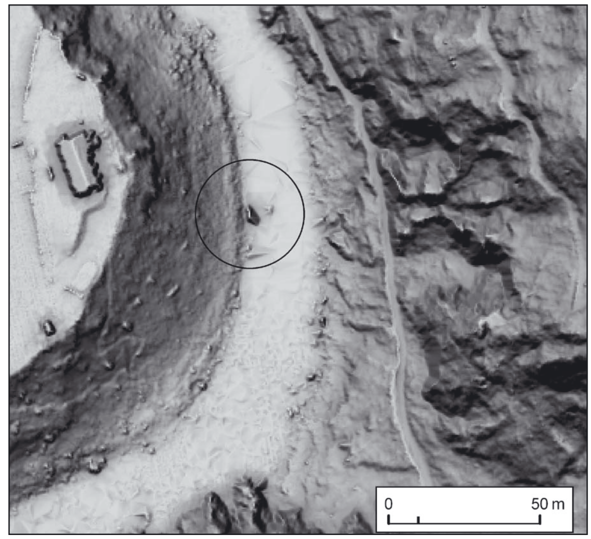


Fig. 21: Za gradom (cat. no. 21), lidar-derived DEM.
Sl. 21: Za gradom (kat. št. 21), DMR izdelan iz lidarskih podatkov.

21

Name: **Za gradom** near **Kobarid** (ID 010609.17)

Description: At low water level of the Soča river an Iron Age spearhead was found.

Due to the reported location and the circumstances of the finding the location seem ambiguous.

Location: In the Soča gorge riverbed. The Za gradom plateau itself is 20 m higher and 41 m to the west. Throwing the object into the river is therefore hardly possible and highly unlikely.

Communications: The location is all but impossible to reach.

Previous research: The find was recovered by the local museum. The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Unknown.

Archaeological interpretation of lidar-derived data (*fig. 21*): No additional features have been recorded.

22

Name: **Čebelnjaki** near **Kobarid** (ID 010609.16)

Description: An iron hammer of undetermined age has been found by means of metal detecting.

Due to the circumstances of the find the exact location is uncertain.

Location: On the eastern slope of the Volnik hill just above a small flat terrace rising on the left bank of the Soča gorge. At the time of this research the site was covered in dense vegetation, predominantly young broadleaf forest. The flat terrace has been used as a meadow.

Communications: See **20**.

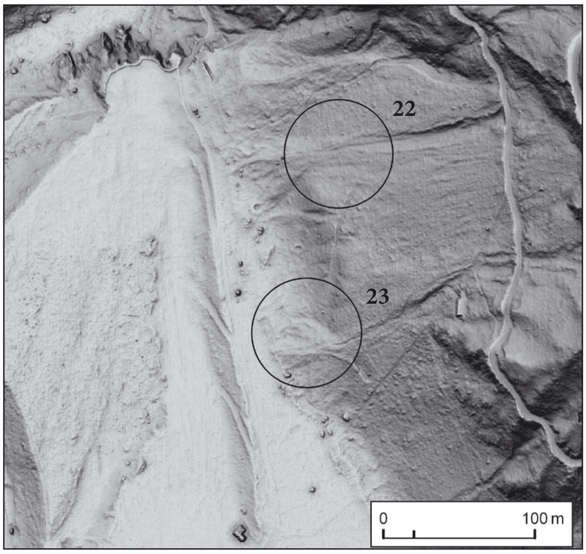


Fig. 22 and 23: Čebelnjaki (cat. no. 22) and V Mevcah (cat. no. 23), lower and upper circle respectively. Lidar-derived DEM.
Sl. 22 and 23: Čebelnjaki (kat. št. 22) – spodaj – in V Mevcah (kat. št. 23) – zgoraj. DMR izdelan iz lidarskih podatkov.

Previous research: The find was recovered by the local museum. The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Unknown.

Archaeological interpretation of lidar-derived data (*fig. 22 and 23*): No additional features have been recorded.

23

Name: **V Mevcah** near **Kobarid** (ID 010609.15)

Description: A spearhead was recovered, possibly of late Hallstatt date (*ARKAS*, ID 010609.15).

Due to the circumstances of the find the exact location is uncertain.

Location: See **22**.

Communications: See **20**.

Previous research: The find was recovered by the Inštitut za arheologijo ZRC SAZU. The location has been robbed by illegal metal detecting.

Potential features in lidar-derived data: Unknown.

Archaeological interpretation of lidar-derived data (*fig. 22 and 23*): No additional features have been recorded.

C. Off-site archaeology

24

Name: Field boundaries

Description: There has been no attempt at recording relict or historical field boundaries, although a lot of them can be traced using historical and modern maps, vertical aero photography and satellite imagery.

Location: Evenly spread in the valley floor, less common on slopes, endemic on plateaus.

Communications: All features are connected to the path network.

Previous research: None.

Potential features in lidar-derived data: Stone-built boundaries or boundaries marked by repeated ploughing, past and present.

Archaeological interpretation of lidar-derived data (*fig. 24*): So far 5.8 km of relict field boundaries and 50 km of historic field boundaries have been recorded. It has to be noted that this is not the final sum since one third of the entire area has not yet been surveyed for this type of features.

25

Name: Paths

Description: The presumed prehistoric path has been recognized on isolated spots or stretches. The longest stretch recorded was from Gradič (**13**) to Tonovcov grad (**12**) (Rutar 1882).

Location: In the Nadiža and Idrija valley floor and on the Kobariški Stol Mountain.

Communications:

Previous research: Parts of the path were recorded in the late 19th c (Rutar 1882) in connection with the sites of Molida (**9**), V laščah (**11**), Gradič (**13**) and Tonovcov grad (**12**). M. Mlinar (Mlinar 2004) describes a part of the track.

Potential features in lidar-derived data: Paths.

Archaeological interpretation of lidar-derived data (*fig. 25*): 384.1 km of various paths have been recorded based on the lidar data. Due to the amount of data the major obstacle was to distinguish between paths of different ages. This was achieved with the use of GIS analyses, and the prehistoric route has been established (Štular 2011a).

26

Name: World War I remains

Description: No World War I remains have been systematically recorded by the archaeological method. Numerous monuments and isolated locations have been described but most are pertaining to the first frontline on the mountain ridges located outside of the research area. The best existing publicly available map containing some data on our research is a model in the Kobariški muzej. However, numerous specialists and enthusiasts are familiar with the locations in detail. Many collections of photographs and descriptions exist, distributed primarily on the

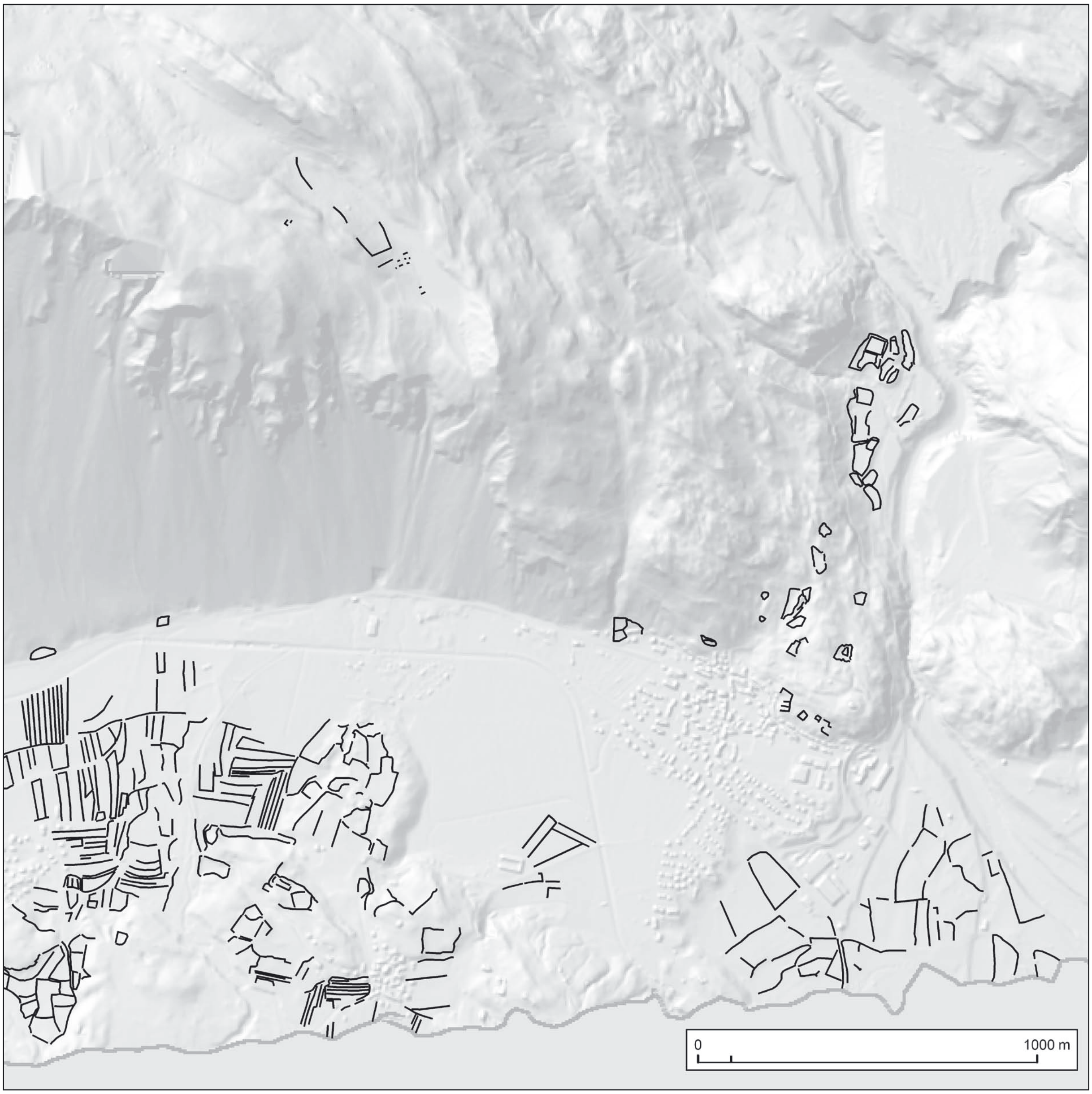


Fig. 24: Field boundaries (cat. no. 24), extract in the vicinity of Kobarid.
Sl. 24: Poljske meje (kat. št. 24), izrez v okolici Kobarida.

internet (e.g. *The walks of peace in the Soča region*) provides numerous links.[1]

Location: Mostly on Kobariški Stol and Matajur Mountains (the 3rd Italian front line) and on the Grmada hill (the 2nd Italian front line).

Communications: All features are connected to the extensive path network.

Previous research: No archaeological research and only limited systematic research; but numerous historical literature exists (see Thompson 2008 for an overview in English).

Potential features in lidar-derived data: Ditches and other earthworks.

Archaeological interpretation of lidar-derived data (*fig. 26*): So far the features in the length of 13.4 km spread on an area of 2.7 km^2 have been recorded. The entire area covered by lidar data has been intensively surveyed for this type of features, but further discoveries are not excluded. All recorded features are situated outside the area registered as the protected cultural heritage.

[1] http://www.potimiruvposocju.si [last checked 1.4.2011].

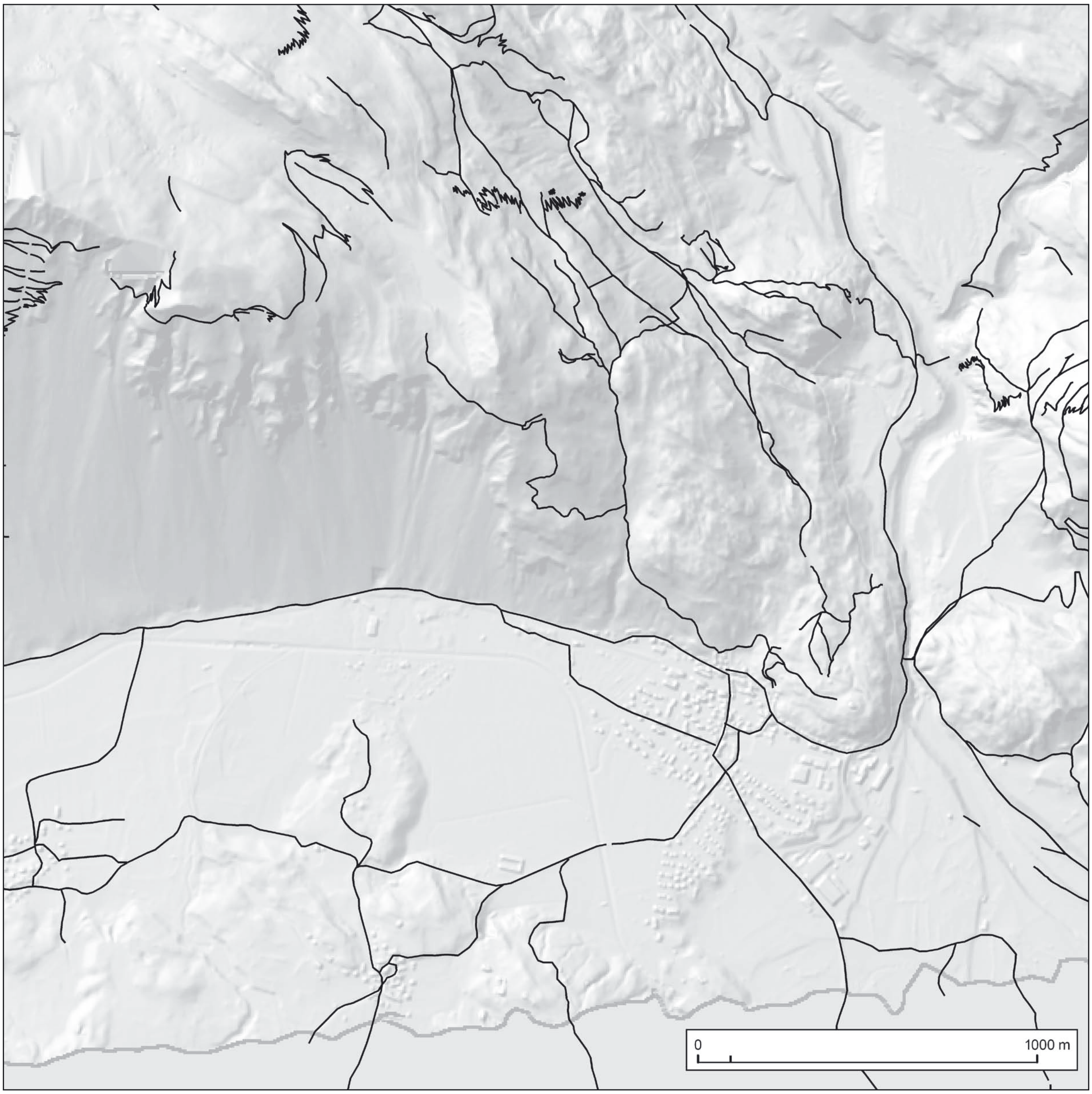


Fig. 25: Paths (cat. no. 25), extract in the vicinity of Kobarid.
Sl. 25: Poti (kat. št. 25), izrez v okolici Kobarida.

CASE STUDY: LATE ANTIQUE SETTLEMENTS IN THE NADIŽA AND IDRIJA VALLEYS

The settlement pattern in the wider Posočje region is not uniform and spans from unfortified settlements in the 4th century to the heavily fortified hilltop settlements in the 6th century. It has to be mentioned, though, that our knowledge is based on just a few well researched settlements and the rest is conjectured on the basis of dispersed information. Within the case study area, the Gradič (**13**) needs to be mentioned as a settlement that likely endured at least into the 4th century (Ciglenečki, Modrijan, Milavec 2011, 33–52). The importance of this area throughout history has been in connection with a route that led from Cividale del Friuli towards the north following the valley of the Nadiža River, through the settlements of Staro selo and Kobarid into the valley of the river Soča to Bovec, and further across the Predel pass and on to Treviso. This route was joined by routes that led towards central Dolenjska via Tolmin and the valley of the river Bača, either across the Sorica pass in Bohinj,

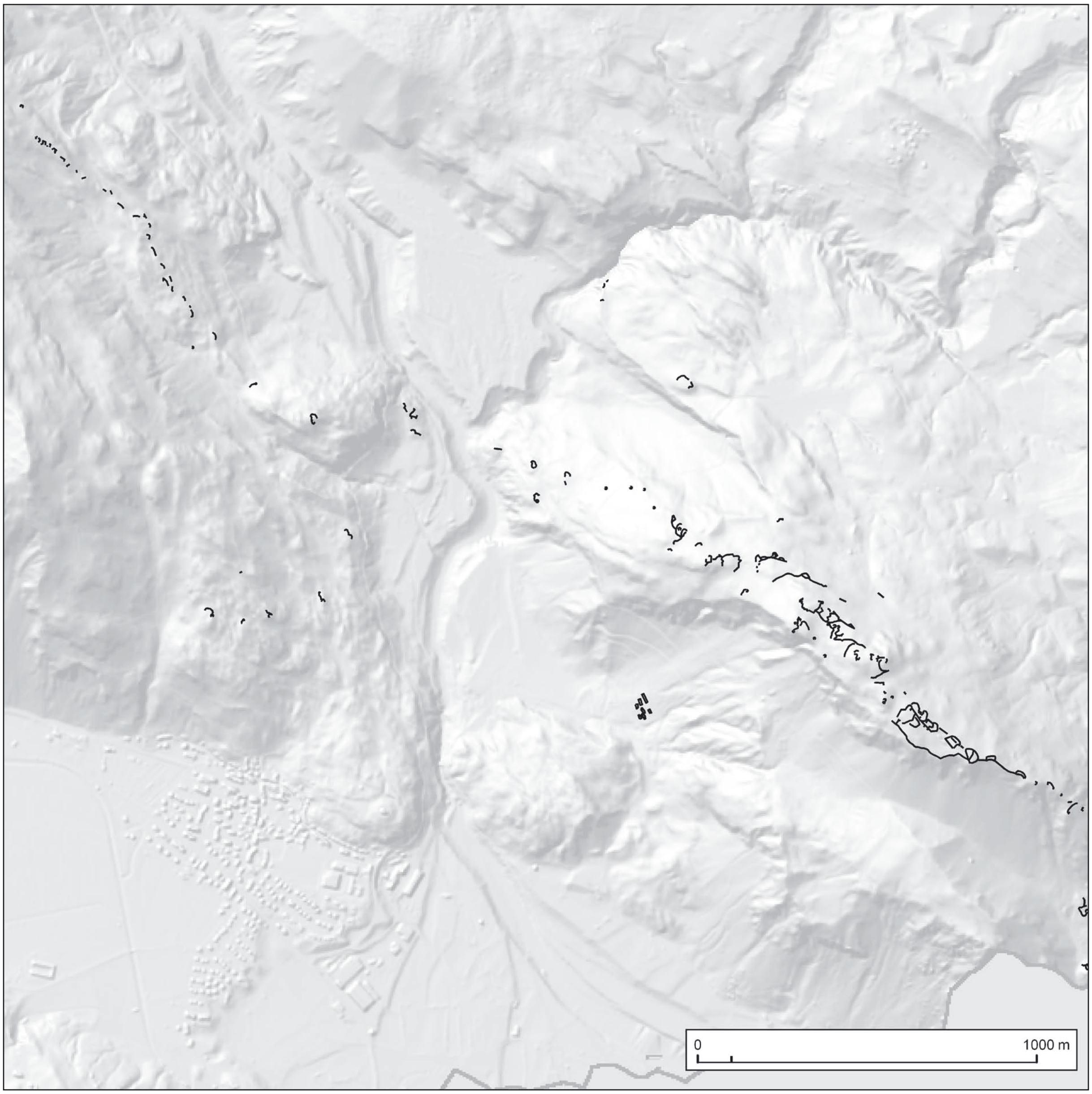


Fig. 26: World War I remains (cat. no. 26), extract in the vicinity of Kobarid.
Sl. 26: Ostanki prve svetovne vojne (kat. št. 26), izrez v okolici Kobarida.

or along the Selška Sora valley towards Škofja Loka (cf. Ciglenečki 1999, fig. 4; Štular 2011).

Using the well-researched Tonovcov grad (**12**) as an analogy, it is possible to establish the similarities and dissimilarities among the supposed Late Antiquity period settlements in the Nadiža and Idrija valleys (*fig. 27*). Unlike other recent overviews (Ciglenečki 1997; Ciglenečki, Modrijan, Milavec 2011, 33–52) the Molida (**9**) and Gradič (**13**) sites have been excluded on the grounds of insufficient data (see above). However, we have included the Sv. Helena (**4**) site, although at present there is no hard evidence to date the settlement in the Late Antiquity period. Evidence does, however, suggest the Late Antiquity date (cf. Ciglenečki, Modrijan, Milavec 2011, 33–52) and this conjecture will be further substantiated below.

First, the Tonovcov grad settlement plan will be analysed (*fig. 12*). Three groups of buildings can be distinguished apart from the churches (cf. Ciglenečki 1994). Group 1 in the central area of the settlement consists of four buildings (*fig. 12:* 1,26–28), including the largest buildings (*fig. 12:* 28) and a building with the largest single room (*fig. 12:* 1)

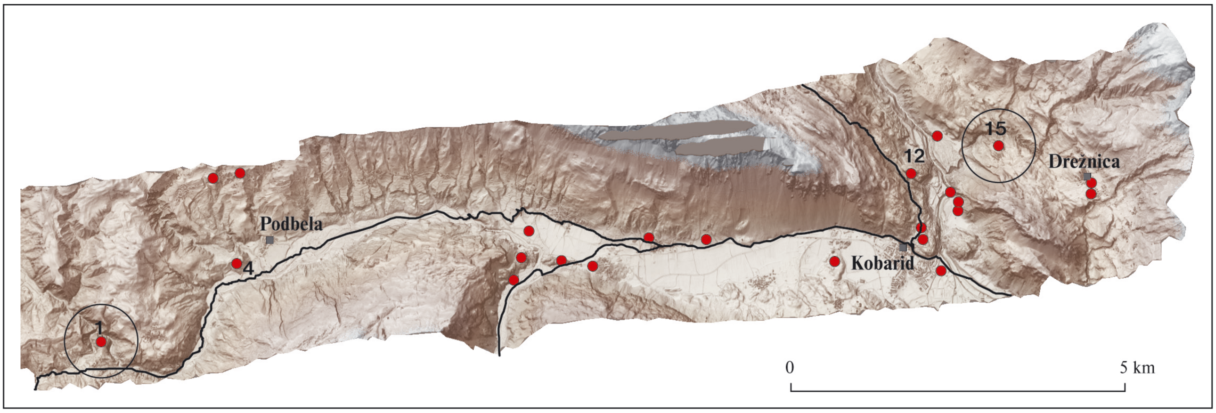


Fig. 27: Kobarid area, Late Antiquity period settlements Gradec (cat. no. 1), Sv. Helena (4), Tonovcov grad (12), Veliki gradec (15), modelled optimal paths (after Štular 2011a) and 500 m circles around presumed fortified refuges.
Sl. 27: Kobariška, poznoantične naselbine Gradec (kat. št. 1), Sv. Helena (4), Tonovcov grad (12), Veliki gradec (15), modelirane optimalne poti (po Štular 2011a) in 500-metrska razdalja okoli domnevnih pribežališč.

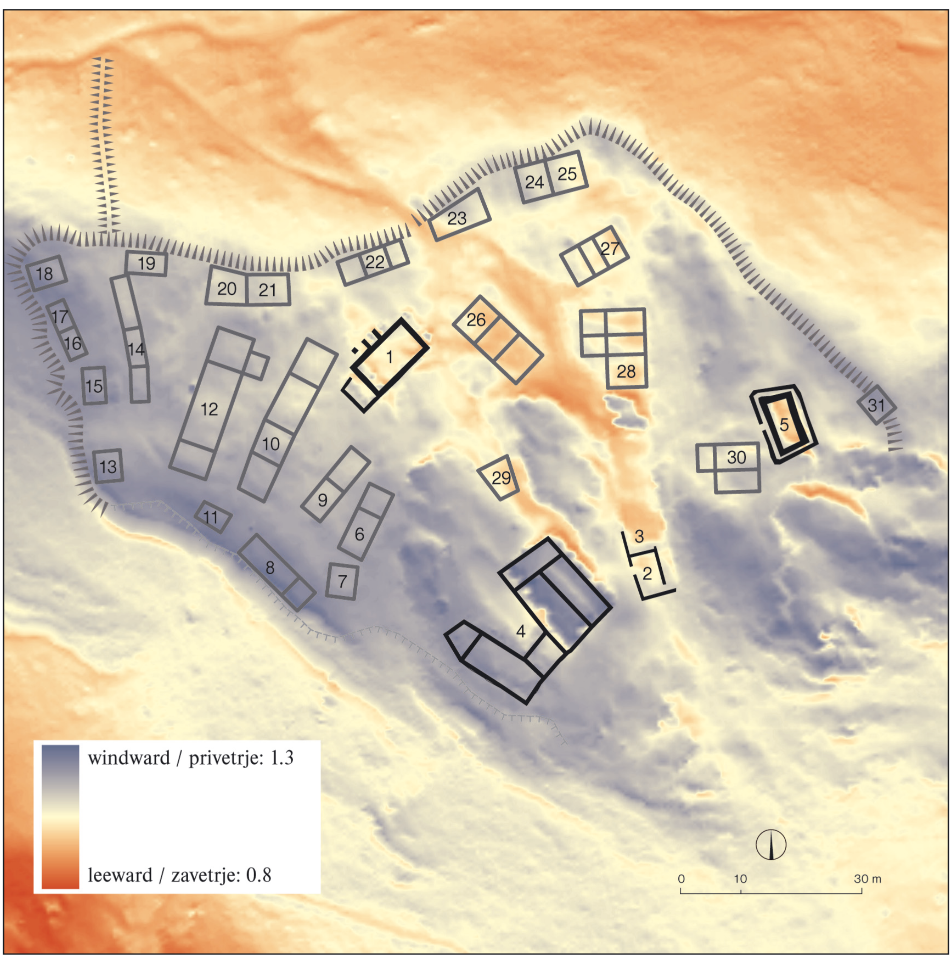


Fig. 28: Tonovcov grad (cat. no. 12), wind exposure. SAGA Wind Effect analysis has been performed on the lidar-derived 0.5 m DEM. Leeward and windward areas at northern wind (azimuth 5 degrees) – prevailing in this area at weather front shifts across the Alps – are shown.
Sl. 28: Tonovcov grad (kat. št. 12), izpostavljenost vetru. Z modulom SAGA Wind Effect smo izračunali izpostavljenost severnemu vetru (ki prevladuje ob premiku vremenske fronte preko Alp) na 0,5-metrskem DMR-ju.

disregarding the church (*fig. 12:* 4). These buildings are all adjacent to the most obvious settlement communications. Group 2 consists of seven multi-cell (*fig. 12:* 8,9,10,12,14,16–17,20,21) and four single-cell buildings (*fig. 12:* 7,11,13,15) in the western part of the enwalled area. Group 3 consists of small buildings attached to the northern settlement walls (*fig. 12:* 18–25). In addition to these there are four scattered small buildings in the southwestern part of the settlement (*fig. 12:* 2,3,29,30).

It has been noted early on that the churches of Tonovcov grad were built on exposed hilltops, whereas some of the other buildings are using the leeward area (Ciglenečki 1994, 3–4). The map of the northern winds (*fig. 28*) demonstrates that it is group 1 that enjoys the leeward position. Group 2 is situated in the least favourable leeward position, whereas group 3 was sheltered from the northern winds by the defensive walls.

The location of the Churches, surprisingly, is not on the location with maximal visibility, neither calculated from within the settlement, nor from the adjacent contemporary road (*fig. 29*). It is, however, above average visually exposed and it is visible from the fields south of Kobarid. The interpretation of building groups cannot be based on the above presented data alone, but group 1 is clearly located in the sheltered central location adjacent to the communication hub. Combined with larger building sizes, the evidence at hand is all suggestive of the settlement functional focus. The symbolic focus of the settlement is obviously the church.

Once the Tonovcov grad settlement layout is known it can be compared with Sv. Helena (**4**). The similarity of the areas (8600 versus 7838 m^2) and perimeters (403 versus 404 m) is noticeable. But the same cannot be said for individual buildings: Tonovcov grad boasts a larger number of detected buildings, 26 versus 6. Keeping in mind that the plan for more than 55% of the Sv. Helena site is unknown, and assuming similar building density on the entire area, the number of Sv. Helena's buildings would still only amount to 14. On average, both buildings and individual rooms are bigger on Sv. Helena (*fig. 30*). Also, no single-cell buildings have been detected on Sv. Helena, whereas there are 10 on Tonovcov grad. Disregarding the one-cell buildings, the buildings on Sv. Helena have on average 2.33 rooms versus 2.5 on Tonovcov grad.

These differences can be attributed to the profound differences in topography. Sv. Helena is very flat, whereas Tonovcov grad's ruggedness represents an average for hilltop enclosures and settlements in general (*fig. 31*). Comparing the terrain morphology with the location and size of each individual building on Tonovcov grad, it becomes evident that each building is precisely adjusted to the local micro-morphology, i.e. each building is as large as the terrain allows for (*fig. 12*).

Since the differences between the two settlements derive from the natural affordance, we shall focus on the similarities. The similar size of the enclosed areas has been mentioned. In addition, the combined built area – i.e. total size of all buildings – of both settlements is similar: 663 m^2 on Sv. Helena and 1592 m^2 on Tonovcov grad would account for 1473 versus 1592 m^2, assuming the similar building density on the entire Sv. Helena area: the 10% smaller Sv. Helena site has an 8% smaller built area.

It has been noted that the largest room on the Tonovcov grad settlement (72.6 m^2) belongs to the church building. Although the rooms are larger on Sv. Helena there is just one building with a room of similar size. That is building No. 2 with a 78.8 m^2 large room. The visibility of this building from the most likely contemporary route confirms that this building is situated on a visually exposed area of the Sv. Helena settlement.

The comparison of Sv. Helena with Tonovcov grad, therefore, exhibits the similarities of an enclosed and built up area and also some similarities of internal planning. This suggests that the intention of the settlement planners was similar: to provide lodging for a similar number of people performing similar day-to-day functional, social and religious activities. On Sv. Helena the topography allowed for buildings that were not only properly proportioned but were also bigger with larger rooms. In order to meet similar needs on Tonovcov grad some particular adaptations of the building template had to be made, such as the outbuildings of group 2. A certain degree of consistency, therefore, allows for an assumption that the planning had been made on similar mental templates and technical knowledge. The earlier dating exposes Sv. Helena as the "original".

Comparing Tonovcov grad with Veliki gradec (**15**) exposes profound differences between the two. In general, the latter is smaller (*fig. 32*) and does not have any stone built buildings. Also, Veliki gradec is remote from the long-distance route although it maintains visual contact with Tonovcov grad. All the evidence is pointing towards the same conclusion: a settlement without public buildings or symbolic functions. Whether it had been permanently settled or not (cf. Ciglenečki 1997, 25), however, can only be confirmed by archaeological excavation.

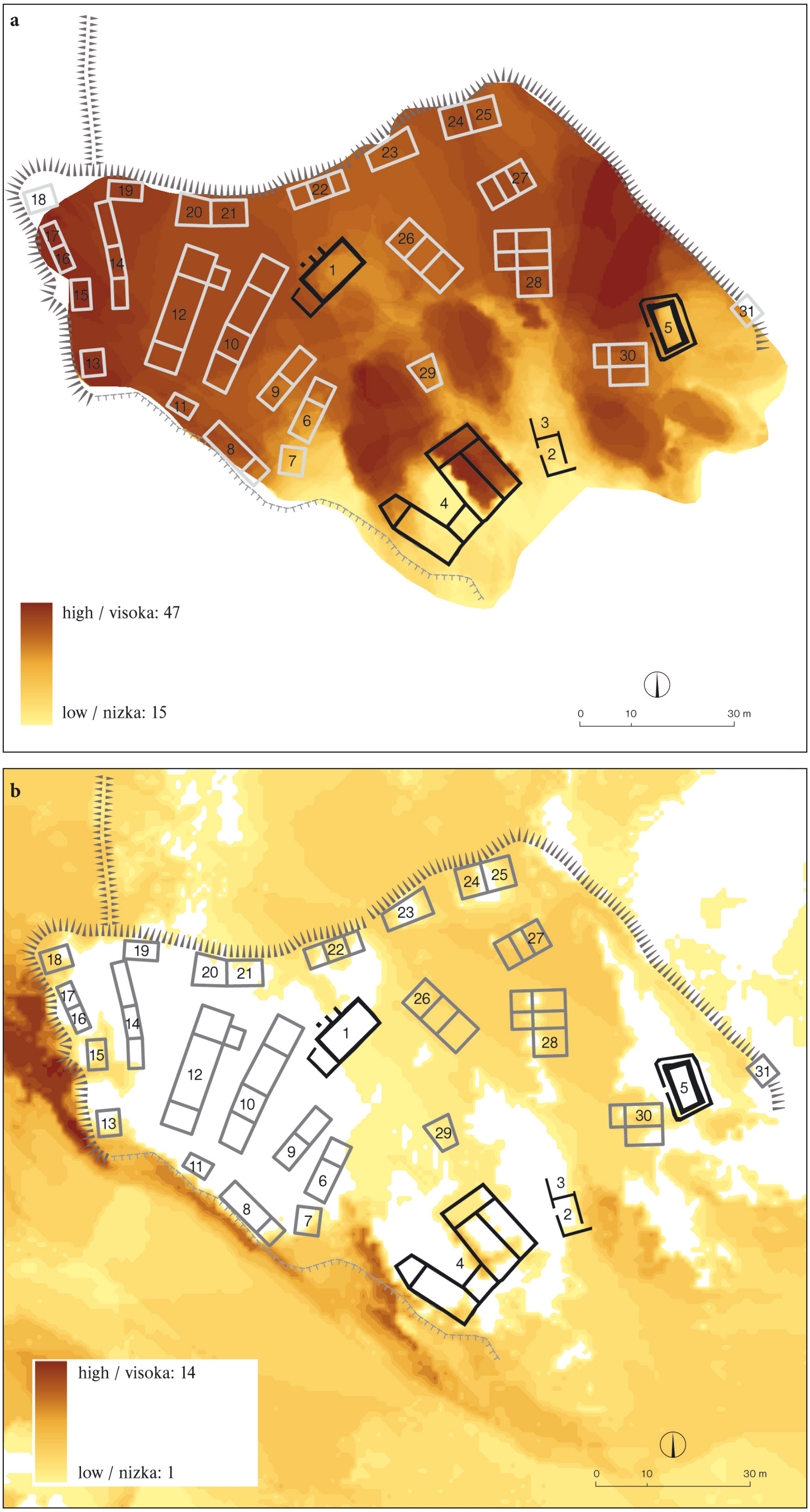


Fig. 29: Tonovcov grad (cat. no. 12), visibility. Viewshed analysis has been performed in ESRI ArcGIS software on the 0.5 m lidar-derived DEM; the observer's height has been set to 1.65 m and the height of the observed feature to 3 m to emulate the height of the church. **a:** visibility within the settlement has been calculated from 50 random points located outside the buildings, **b:** visibility from 15 points located on the contemporary path – 500 metres from the settlement in each direction – has been calculated.

Sl. 29: Tonovcov grad (kat. št. 12), analiza vidnosti. Analizo smo izvedli s programom ESRI ArcGIS na 0,5 metrskem DMR-ju; višina opazovalca je 1,65 metra, višina opazovanih objektov 3 metre. **a:** vidnost znotraj naselbine smo izračunali iz 50 naključno izbranih točk znotraj naselbine, **b:** vidnost zunaj naselbine smo izračunali iz 15-tih točk, ki smo jih enakomerno razporedili na sočasni poti, 500 metrov od naselbine.

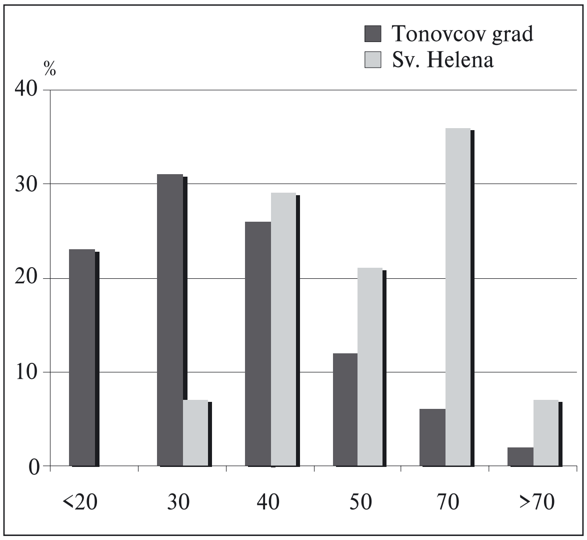


Fig. 30: Tonovcov grad (cat. no. 12) and Sv. Helena (cat. no. 4), comparison of the room sizes. The graph shows the percentage of rooms in individual size brackets (under 20, 20–30, 30–40, 40–50, 50–70 and beyond 70 m^2) for the two sites.
Sl. 30: Tonovcov grad (kat. št. 12) in Sv. Helena (kat. št. 4), primerjava velikosti prostorov. Graf prikazuje odstotek posameznih velikostnih razredov prostorov (do 20, 20–30, 30–40, 40–50, 50–70 in nad 70 m^2) na obeh najdiščih.

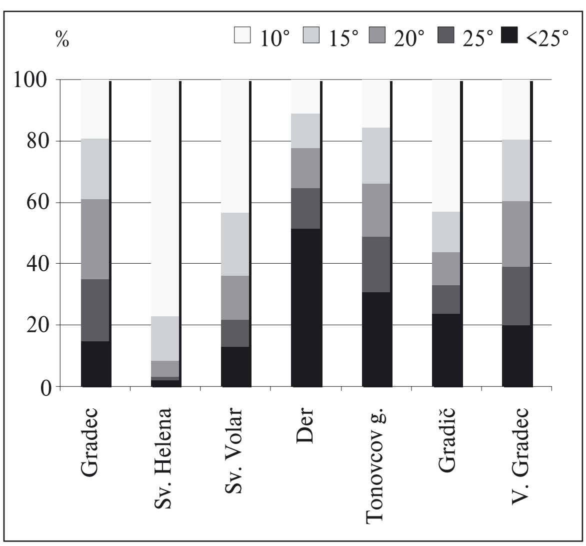


Fig. 31: Hilltop enclosures, comparison of the slope gradients in degrees.
Sl. 31: Višinske naselbine, primerjava naklonov v stopinjah.

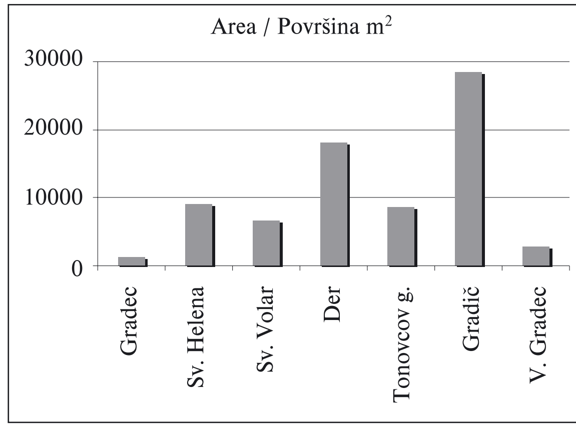


Fig. 32: Hilltop enclosures, comparison of the area in square metres.
Sl. 32: Višinske naselbine, primerjava površine v kvadratnih metrih.

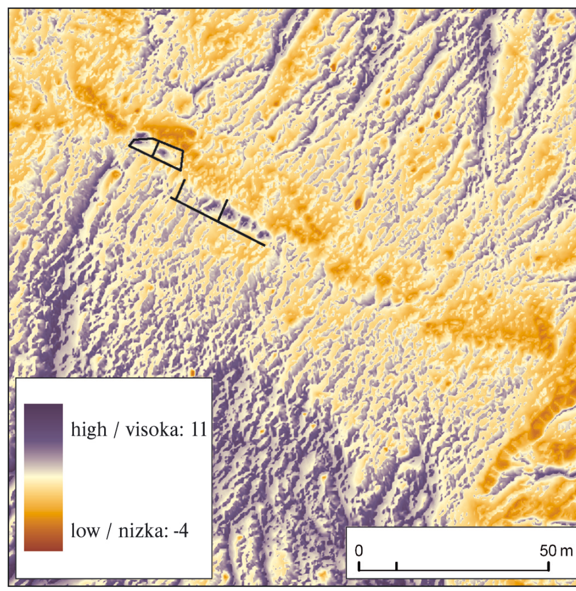


Fig. 33: Gradec (cat. no. 1), soil wetness. The water saturation has been calculated with the SAGA Wetness Index (SWI) on 0.5 m lidar-derived DEM. SWI is a compound topographic index derived from several topographic attributes. It reflects the tendency of water to accumulate in the soil at a point in the landscape (accumulated drainage), countered by the tendency of the soil to transmit this water, i.e. slope (Boehner et al. 2002; Andersson 2009).
Sl. 33: Gradec (kat. št. 1), namočenost prsti. Namočenost prsti smo izračunali z modulom SAGA Wetness Index (SWI) na 0,5-metrskem DMR-ju. SWI je topografski indeks, ki odraža na eni strani tendenco zadrževanja vode (akumulacija) in na drugi strani tendenco prsti, da odvaja vodo (naklon) (Boehner et al. 2002; Andersson 2009).

The Gradec (**1**) site has no building remains and is significantly smaller even than Veliki gradec (**15**, *fig. 32*). In addition, more than half of the flattened area exhibiting anthropogenic alterations is prone to saturation with rainfall water (*fig. 33*). This factor is of particular importance for this site, since it is located within the area of highest rainfall in Slovenia exceeding 3000 mm (*ARSO* 2006, 4). On the other hand, this site is adjacent to and highly visible from the same route as Sv. Helena (**4**). The interpretation of this site is ambiguous: on the one hand, the traces of human activities in the 6th century are slight but undeniable, yet on the other hand any kind of permanent settlement is highly unlikely. At this point it can only be deduced that the activities taking place on this site were not related to hiding from people moving to or from the Friuli plain using the path bypassing Gradec (**1**) and Sv. Helena (**4**) sites (cf. Štular 2011a).

The further discussion of the Late Antiquity period settlement in the Posočje area is beyond the scope of this short case study. However, the use of lidar-derived data beyond mere mapping of features has been, we hope, clearly demonstrated.

CONCLUSION

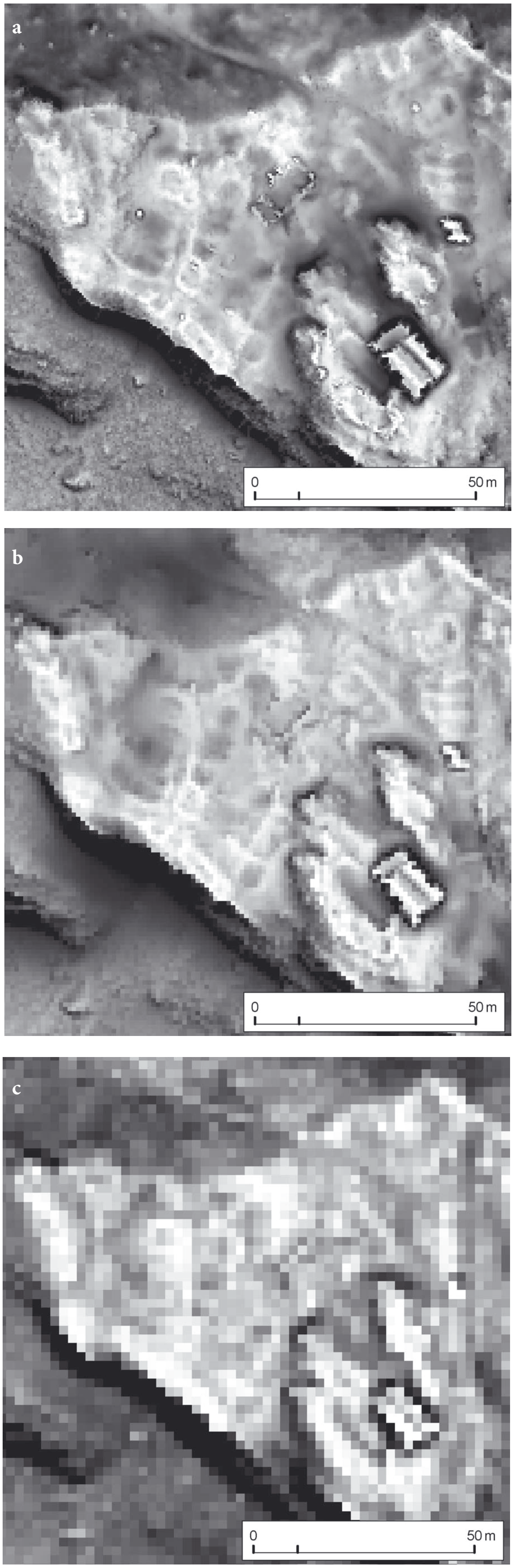
The aim of this article has been to demonstrate the extent and nature of the new archaeological information that can be extracted from lidar-derived data. First, the relatively low number of newly discovered archaeological features in the Kobarid region needs to be commented. The extent of these perhaps fails to meet the expectations of the experienced lidar interpreter or archaeologists working in other areas (e.g. Georges-Leroy et al. 2009). This can partially be explained by the specific landscape context. For example, in North Europe and Great Britain lowlands studies, the reforested medieval ridge and furrow features often account for a majority of reported newly discovered features (e.g. Sittler 2004; Sittler, Schelleberg 2006; Carey et al. 2006; Challis et al. 2008; Hesse 2010). But these features are scarce in mountainous areas of Southern Europe due to different agricultural techniques used in the Middle Ages (e.g. LeGoff 1988, 55). The explanation for the fact that no archaeological sites that would have been completely unknown have been discovered is simple: all the sites with detectable above-ground traces have been discovered during 120 years of archaeological research.

Newly discovered archaeological features within known archaeological sites allow for some important conclusions. The analysed sites can be divided into three groups. In the first group are the sites for which crucial new information has been recorded. This group consists entirely of hilltop enclosures from all periods and types (**1, 4, 6, 8, 12, 13, 15, 17**). Lidar-derived data enabled mapping of the sites; in the cases of Sv. Helena (**4**) and Gradič (**13**) sites new interpretations could be drawn. Methodologically important is the case of Tonovcov grad (**12**). This is the only site in this group that has been previously mapped since it has been intensively researched for over two decades. Still, important additional information was gathered. Most of these sites are remote and hence endured only low-level human activity after the sites were abandoned. On the other hand, these locations are nowadays forested and hence "muddy boots" archaeological topography is difficult and any kind of remote sensing apart from lidar impossible. Thus we were able to evaluate some assumptions made by C. Marchesetti over one hundred years ago before the reforestation of the landscape in question.

In the second group belong the sites for which new information has been gathered but is not of critical importance for the site's interpretation. For the presumed Roman period settlements either anthropogenic earthworks of unknown date and function have been recorded (**3**), or else a complete absence of any man-made features has been noticed (**7**). In one case (**11**) new data improved the existing knowledge by providing the exact location of a possible site. In the case of a burial mound (**10**), the assumption that any kind of mound exists nowadays at the assumed location has been negated. Lidar-derived data cannot, however, be used to comment on the possibility that the mound had been ploughed away in the last century. Had the area still been used as arable land that conclusion would be possible using aerial photography.

In the third group are the sites for which no new data have been recorded. This group consists of levelled (non-burial mound) cemeteries (**2, 6, 14, 16**) and a cave site (**5**). Regardless of the type of the site, all sites that are nowadays built up (**14, 16**) would have belonged into this group. Lidar-derived data are not suitable for analyses of this type of sites and we are not aware of any such published examples.

Due to the absence of newly discovered sites we felt it necessary to include a case study of the settlements of the Late Antiquity period to demonstrate the full potential of lidar-derived data. Comparing the plans of the two settlements (**4, 12**), a certain degree of consistency allows for an assumption that the planning behind had been made on similar mental templates and technical knowledge. The somewhat surprising results of the viewshed analysis demonstrated that the visibility of the churches was not decisive for the choice of location. The functional factors such as leeward position for the biggest houses seem to have prevailed. The comparison of the two supposed fortified refuges (**1, 15**) revealed



not only the differences in comparison to the fortified settlements but also between the two. The latter are of such proportion that the two sites could not have been used for the same purpose.

In comparison to the data recorded on the archaeological sites the extent of off-site features recorded for the first time – WWI remains (**24**), paths (**25**), and relict field boundaries (**26**) – is astounding. One reason for this is that these archaeological remains are yet to be integrated into systematic archaeological research in Slovenia and have no research history to speak of (cf. Predovnik 2008; Gaspari 2008b; Štular 2008; Predovnik, Nabergoj 2010). The huge number of recorded WWI features, for example, has not been recorded in archaeological databases but is known to local heritage caretakers (e.g. *The walks of peace in the Soča region*[2]), enthusiasts and metal detector robbers alike. The large number of these features and the area that they cover on one hand, and the lack of previous archaeological research on the other hand, seems to be the "earth-shattering" factor where the use of lidar-derived data demands theoretical reconsiderations within archaeology.

In conclusion, the expected near-future development of the lidar-derived data applications in archaeology has to be discussed. The use of lidar-derived DEMs, once processed, demands neither expensive equipment nor extensive additional training. This combined with the total lidar coverage expected shortly in some European countries (e.g. the Netherlands, Denmark, England, Czech Republic and Slovenia; Štular et al. 2011) is a promise for a further growth in popularity, and the use of lidar-derived data is on the verge of becoming a recognized standard archaeological tool. The differences in quality of "lidar" data need to be stressed. The data provided by large-scale mapping projects are usually aimed at producing DEMs with a 2-metre grid. Judging by the specifications given in call to data suppliers, similar data resolution can be expected in Slovenia,

[2] http://www.potimiruvposocju.si [last checked 1.4.2011].

Fig. 34: Tonovcov grad (cat. no. 12), extract of the site visualized with Sky view factor. DEMs with grid sizes 0.5m (**a**), 1m (**b**) and 2 metres (**c**) are shown. Aggregating with random cells simulates coarser lidar-data acquisition.
Sl. 34: Tonovcov grad (kat. št.12), izsek najdišča, prikazan s faktorjem odprtosti neba. Prikazani so DMR-ji z velikostjo celic 0,5 m (**a**), 1 m (**b**) in 2 metra (**c**). Bolj grobo lidarsko snemanje smo simulirali z naključnim izborom celic pri združevanju.

at least in forested areas. A DEM with 2-metre grid provides 93.75% les data-points – and thus carries much less information – compared to the 0.5-metre grid used in this case study. Data of the former type are suitable for example for geoarchaeological studies (Challis 2006; Mlekuž 2009, 13–15) and for some of the analysis presented in the above case study, but not for feature extraction (*fig. 34*). In the foreseeable future lidar data used for archaeological feature extraction will more often than not still have to be commissioned, which hinders the full potential of lidar in archaeology.

Abbrevations / okrajšave

ARKAS = *Arheološki kataster Slovenije* (Service provider / skrbnik: ZRC SAZU). http://arkas.zrc-sazu.si [last checked / zadnji dostop 1.4.2011].

ARSO 2006 = *Podnebne razmere v Sloveniji (Obdobje 1971–2000)* (Service provider / skrbnik: ARSO, MOP RS). http://www.arso.gov.si/vreme/podnebje/podnebne_razmere_Slo71_00.pdf [last checked / zadnji dostop 1.4.2011].

RNKD = *Register nepremične kulturne dediščine* / Registry of unmovable cultural heritage (Service provider / skrbnik: RC ZVKDS, MK). http://giskds.situla.org/giskd [last checked / zadnji dostop 26.1.2011].

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Uporaba modelov reliefa pridobljenih z lidarskim snemanjem v arheološki topografiji

Študijski primer Kobariške

Povzetek

Lidarsko snemanje zemeljskega površja je trenutno najbolj natančna tehnika za izdelavo digitalnih modelov površja. Izraz lidar je okrajšava za *Laser Imaging Detection and Ranging* oziroma LIght Detection and Ranging, torej svetlobno zaznavanje in merjenje razdalj. Te meritve so omogočili odkodiranje signala globalnega pozicioniranja (GPS) za civilno uporabo, razvoj natančnih naprav INS (*inertial navigation system*), lidarskih sistemov in predvsem razvoj robustnih algoritmov v zadnjem desetletju. Lidarske podatke uporabljamo v geologiji, gozdarstvu, arheologiji, hidravličnem modeliranju itd. V arheologiji je lidar prvi uporabil Stan Sever daljnega leta 1985 (Sheets, Sever 1988). Vendar takrat niti NASA ni razpolagala z dovolj zmogljivimi računalniki za obdelavo podatkov, zato je bilo na prve vesti o uporabi lidarja v arheologiji potrebno počakati do leta 2001 in še nekaj let na uporabne rezultate (v Sloveniji Kokalj 2008; Štular 2008; Mlekuž 2009; Budja, Mlekuž 2010; Kokalj, Zakšek, Oštir 2011; Štular 2011a). V arheologiji na podlagi lidarskih podatkov opazujemo predvsem drobne spremembe površja, ki v določenih pogojih razkrivajo pokopano arheologijo. V tem prispevku izhajamo iz podatkov, ki smo jih pridobili z analizo polmetrskega digitalnega modela (Kokalj 2008, 322–323) na kobariškem območju (*karta 1*).

Obravnavamo sedemnajst registriranih arheoloških najdišč, šest posamičnih najdb in tri sklope zunajnajdiščnih arheoloških podatkov. Želimo predvsem prikazati medsebojni odnos že znanih arheoloških podatkov in podatkov, pridobljenih iz digitalnega modela. Zato smo predhodno znane arheološke podatke obravnavali ločeno od podatkov, ki smo jih pridobili iz digitalnega modela. Tako smo dobili objektivno sliko o pomenu lidarskih podatkov.

Obravnavana najdišča (*sl. 1–26*) s stališča novih podatkov razdelimo v tri skupine. V prvi so najdišča, o katerih smo pridobili ključne nove podatke. To so višinske naselbine iz vseh arheoloških obdobij (kat. št. **1, 4, 6, 8, 12, 13, 15, 17**). Lahko smo izdelali načrte vseh že znanih najdišč, ki v primeru najdišč Sv. Helena (**4**) in Gradič (**13**) omogočajo povsem nove interpretacije (*sl. 4, 13*). Z metodološkega stališča je pomemben podatek, da je bil na podlagi lidarskih podatkov izboljšan tudi načrt poznoantične naselbine Tonovcov grad (**12**), ki je predmet večdesetletnega intenzivnega raziskovanja. Razlogi za tako dobre rezultate so v kombinaciji okoliščin. Večinoma gre za odmaknjene lokacije, na katerih so bili človekovi posegi v času po opustitvi najdišč minimalni. Na drugi strani gre večinoma za bolj ali manj gozdna območja, ki jih je s klasično arheološko topografijo težko natančno raziskati, za vse ostale tehnike daljinskega zaznavanja pa so popolnoma nedostopna. Tako smo prvič lahko komentirali nekatere domneve C. Marchesettija, kar zaradi zaraščanja zlasti po drugi svetovni vojni doslej ni bilo mogoče.

V drugo skupino sodijo najdišča, o katerih smo pridobili nove podatke, ki pa k vedenju o posameznem najdišču ne prispevajo ključno. V primeru domnevnih rimskodobnih naselbin smo dokumentirali obstoječe antropogene nasipe (**3**) oziroma odsotnost kakršnihkoli znakov na površju (**7**); v enem primeru smo z novimi podatki potrdili domneve in nekoliko izboljšali kakovost arheološkega podatka (**11**). V primeru domnevnega gomilnega grobišča (**10**) smo ovrgli domnevo, da bi gomila na opisani lokaciji še obstajala. S preučevanjem lidarskih podatkov pa ne moremo preveriti, če ni bila gomila na primer uničena z oranjem v zadnjih sto letih, kar bi omogočala ciklična uporaba aerofotografije na njivskih površinah.

V tretjo skupino sodijo najdišča, o katerih z analizo lidarskih podatkov nismo pridobili novih arheoloških podatkov. To so plana grobišča (**2, 6, 14, 16**) in jamsko najdišče (**5**). V to skupino bi zagotovo uvrstili vsa najdišča na urbanih območjih, četudi bi ne šlo za plani grobišči (**14, 16**). Povsem pričakovano je, da analiza lidarskih podatkov ni primerna za raziskovanje tovrstnih najdišč in take uporabe v literaturi ne zasledimo.

V študijskem primeru analize poznoantičnih naselbin (**1, 4, 12, 15**) smo želeli opozoriti predvsem na nekatere metode, ki jih omogočajo lidarski podatki. Primerjava načrtov poznoantičnih višinskih naselbin (**4, 12**) je pokazala, da gre za naselbini, načrtovani po zelo podobnem načrtu (*sl. 4, 12, 30–32*). Nekoliko presenetljivi so rezultati analiz vidnosti, ki so pokazali, da vidnost bodisi znotraj naselbine, bodisi s sočasne poti ni bila ključna za izbiro lokacije cerkva (*sl. 29*). Bolj pomembna je bila, kot se zdi, razporeditev stavb glede na izpostavljenost prevladujočih vetrov (*sl. 28*). Z natančno primerjavo domnevnih pribežališč (**1, 15**) smo pokazali, da gre za dve zelo različni najdišči (*sl. 1, 15, 31, 32*).

V zaključku velja poudariti dve stvari. Uporaba zelo natančnih modelov reliefa v arheoloških raziskavah ima v Sloveniji dolgo tradicijo (Mušič, Slapšak, Perko 2000) in je v določenih primerih lahko izjemno učinkovita. Lidarska tehnologija omogoča, da pridobimo kakovostnejše podatke za velika območja z mnogo manjšimi stroški. Na drugi strani pa velja opozoriti na različno kakovost zajemanja lidarskih podatkov. Podatki, ki bodo v letu 2012 na voljo za vso Slovenijo, bodo predvidoma omogočali izdelavo dvometrskih modelov. V primerjavi z modelom, uporabljenim v tem prispevku, to pomeni bistveno manj podatkov oziroma 93,75 odstotka manjšo gostoto celic digitalnega reliefa (*sl. 34*).

Benjamin Štular
Inštitut za arheologijo
Znanstvenoraziskovalnega centra SAZU
Novi trg 2
SI-1001 Ljubljana
bstular@zrc-sazu.si