A Roman gold mining district in eastern Austria
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(to be refernced as follows: Cech. B., *A Roman gold mining district in eastern Austria*, Historical Metallurgy 46 (2), 2012 (published in 2014), 66-77.)

ABSTRACT: A Roman gold mining district where hydraulic techniques were used to exploit placer gold was recently discovered on the Karth, a wooded plateau in the foothills of the Eastern Alps about 80km to the south of Vienna. The archaeological features, such as the course of several leats, various water tanks and related opencasts are extraordinarily well preserved. Examples of the numerous wood working, smithing and mining tools that have been found in the mining district are presented. The article gives an overview of the first field survey and aims to introduce this exciting site to a wide audience.

Introduction

The Roman gold mining district described here is situated on a plateau called *Karth* about 80 km to the south of Vienna in the foothills of the Eastern Alps. There are well-preserved remains of Roman mining activity in the form of leats and a series of associated tanks. Numerous Roman objects such as coins and various tools have also been found all over the *Karth*. In 2010 a field survey in connection with a project on medieval castles was carried out in the *Karth* by Thomas Kühtreiber. In the course of this survey local historians showed him ancient pathways and enclosures surrounded by ramparts of unknown date which have been variously interpreted as prehistoric sanctuaries, fortifications of unknown date, water tanks of unknown purpose or loam pits (Cech and Kühtreiber 2013, 5-8).

The fact that steep channels lead from these enclosures into deep washed-out gullies made Kühtreiber think that the pathways could have been leats and the enclosures tanks where water was collected for hydraulic mining. A first field survey by the author of this article led to the identification of these features as the remains of Roman gold mining. The leats leading to the tanks are cut by medieval pathways and must therefore be of an earlier date. The dating of the archaeological remains to the Roman period is supported by numerous Roman artefacts and coins that have been found in the area over the past decades. Washing for gold in the *Karth* on a small scale is also attested by 16th-century written sources (Cech and Kühtreiber 2013, 5).

Field survey comprising detailed studies of lidar scans of the area and extensive field walking as well as a reassessment of the Roman finds followed the identification of gold mining in preparation for a future research project (Cech and Kühtreiber 2013). So far five mining areas with nine water tanks have been identified. The six largest and best preserved of these tanks were documented in more detail (see below).

Whilst hydraulic mining as described by Pliny the Elder in his *Historia Naturalis* is very well known and documented in NW Spain (Domergue 1990; 2008; 2012) – Las Médulas being the most famous of these sites (Sánchez-Palencia *et al* 1999; 2008; López 2005) – as well as in Britain (Timberlake 2004), for example Dolaucothi in Wales

(Burnham and Burnham 2004), it was unknown in the Eastern Alps until the discovery of this gold-mining district.

Hydraulic mining

The Romans, being brilliant hydraulic engineers, used the power of water to mine placer gold in secondary alluvial deposits in which the gold is unevenly distributed. The power of water can be used in mining either by releasing a great torrent of water from the tanks (hushing) or by water being led continuously over the deposit (hydraulicking) (Craddock 1995, 87-92), though in practice it is very difficult to determine which technology was used. Bird (2001) has employed the term ground sluicing as an alternative. This involves directing a powerful stream of water from a reservoir onto a soft ore deposit, in order to fragment and break it up; the resulting debris is thereby carried downhill into channels or sluices where any gold can be separated from the waste rock. However, in order to avoid terminological confusion, it seems better to use the general term hydraulic mining.

The archaeological remains of this mining technique are leat channels leading to tanks above the part of the deposit to be mined, and steep and heavily eroded channels leading from the tanks to the opencasts. In 73 AD Pliny was *procurator* of *Hispania Tarraconensis* (NW Spain) where he must have seen hydraulic mining, and gives an excellent description of this mining technique from the construction of the leats and water tanks to the washing of the fine debris: 'At the end of the drop on the brow of the mountain they dig out reservoirs, 200 [Roman] feet [59.2m] on each side and 10 [2.96m] in depth. In these they leave five outlets roughly three feet square, so that when the tank is full and the blocks are struck away a torrent shoots out with such force that it can roll boulders forward. Even now there is another task on level ground: Ditches are dug out – they call them *agogae* – through which the torrent of water can flow, and they are strewn at intervals with *ulex*. This bush is like rosemary, rough and able to catch the gold. The sides [of the ditches] are lined with boards. … The *ulex* (from the *agogae*) is dried, burnt and its ash washed over grassy turf so that the gold settles.' (Pliny, *Historia Naturalis* 33. 75-77).

The Roman gold mining district on the *Karth*

Topography and geology

The Roman gold mining district is situated on a wooded plateau called *Karth* to the southeast of the town of Neunkirchen in Lower Austria between the motorways S6 and A2. It lies in the foothills of the Eastern Alps covering an area of about 2.5 by 6 km (Fig 1). It is bordered to the north by the Vienna Basin (*Wiener Becken*) and to the east, south and west by valleys (*Pittental*, *Hassbachtal* and *Tobelbachgraben*). Due to the scarcity of water on the *Karth* there are very few settlements and very little agricultural activity except forestry, which is the reason for the excellent state of preservation of the archaeological remains.

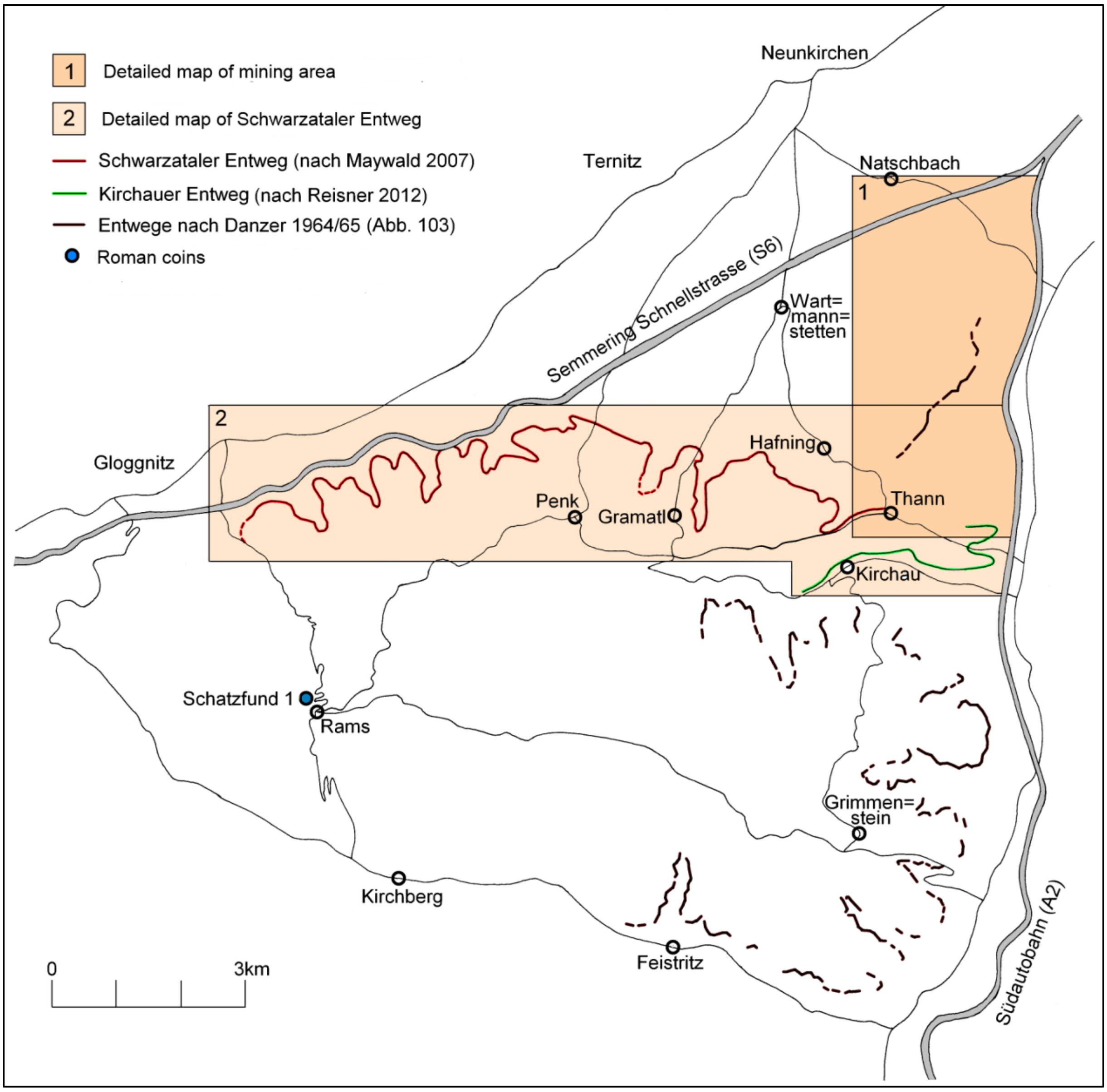

Figure 1: Location map of the Roman mining district (shown in more detail in Fig 3) and the courses of the leats (A = Schwarzataler leat; B = Kirchauer leat; C, D, E = other leats).

Geologically speaking the *Karth* is part of the *Loipersbacher Rotlehmserie*, which is a massive accumulation of scree consisting of reddish to greenish loam interspersed with layers of weathered quartz and quartzite. It is in this formation that the gold is found in the form of placer deposits (Fig 2). The *Loipersbacher Rotlehmserie* sits on top of the *Rohrbacher conglomerate*, an alluvium deposited by the predecessor of today's Schwarza river. Fossils found in this alluvium date it to the latest phase of the early Pliocene (5-6 million years ago). Heavy rains during the later Pliocene and the earliest Pleistocene eroded the mountains to the south and deposited the scree known as *Loipersbacher Rotlehmserie* on top of the *Rohrbacher conglomerate* (Fuchs *et al* 2008).

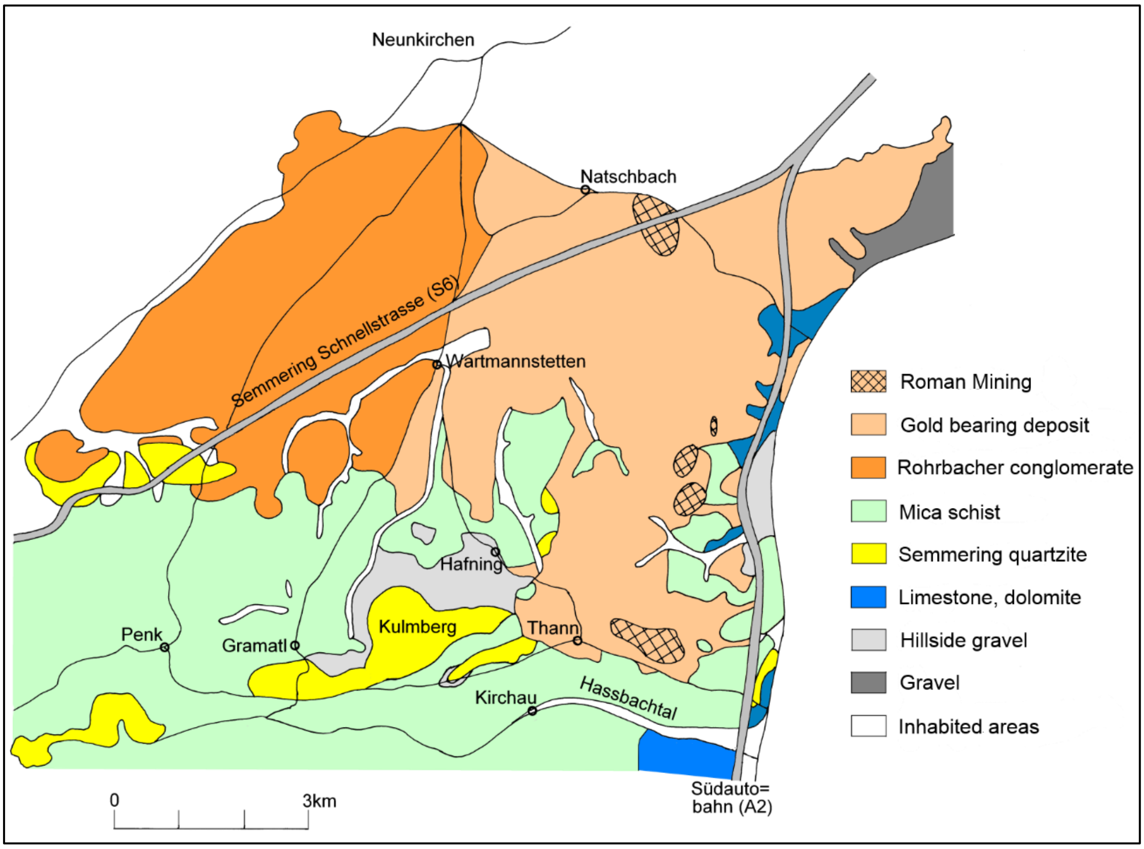

Figure 2: Geology of the Roman mining district (after Fuchs et al 2008).

The mining areas and the water tanks

Each of the five identified mining areas (Fig 3) consists of one or more water tanks and steep channels leading downhill from the tanks into deep, heavily washed-out opencasts with the spoils from mining and washing accumulated as alluvial fans at their lower ends. Smaller tanks in the lower sections of the opencasts might have been used for collecting water for the washeries.

The water tanks were dug into the hillside and the spoil from these excavations was used to construct the embankments. Their shape and size vary according to their topographical situation; they are rectangular, triangular or roughly ellipsoid (Table 1 and Figs 4-6). The surviving height of the embankments suggests that they were quite deep (*eg* Fig 7). Each tank has one inlet for the leat (*eg* Fig 9) and one or two outlets leading to the hushed opencasts (*eg* Figs 8 and 10). In some cases the leat channels leading to the tanks are still visible.

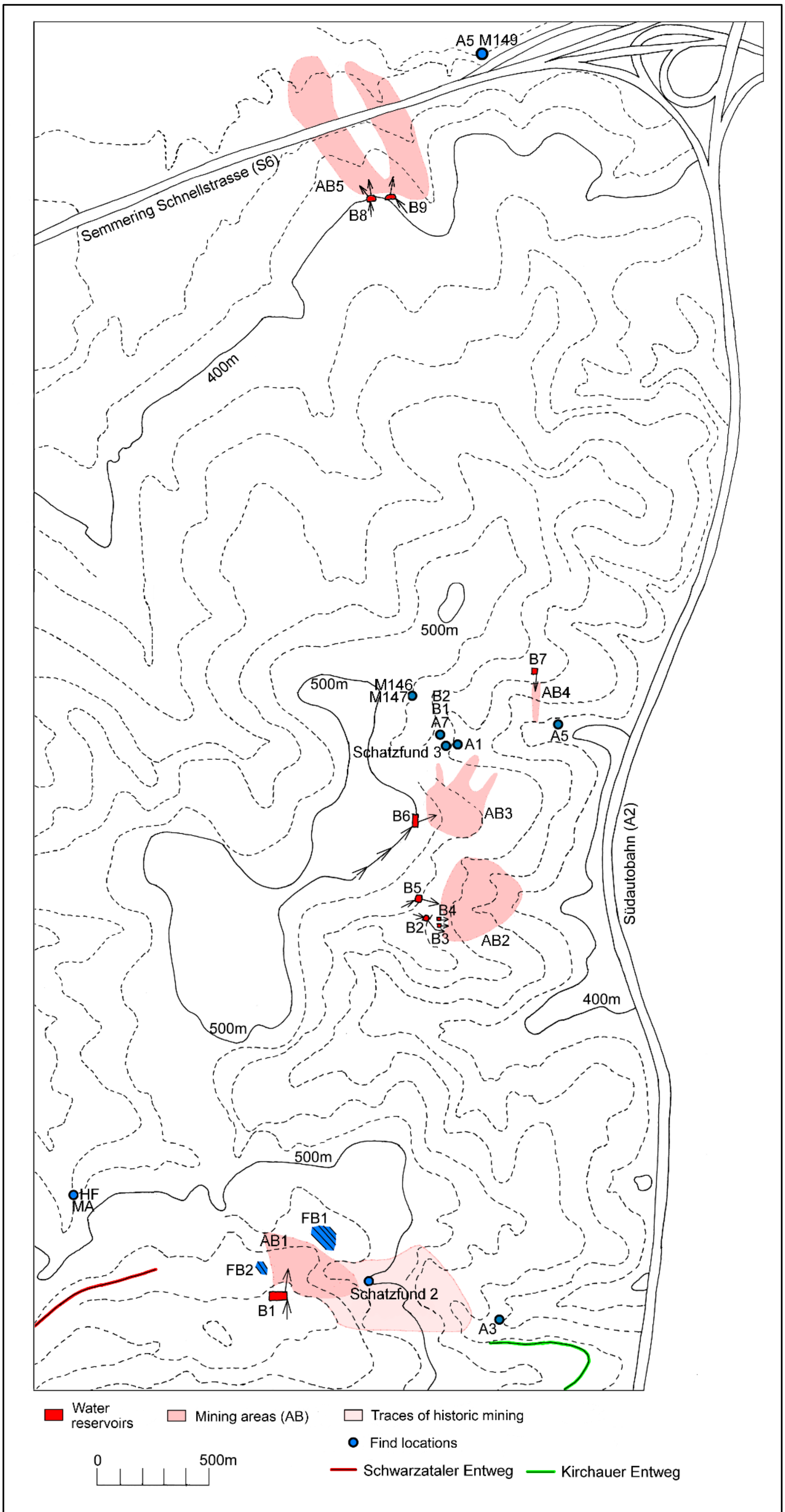

Figure 3: The Roman mining district on the Karth showing the mining areas (MA), water tanks (T) and accumulations of finds (AF). A = Schwarzataler leat, B = Kirchauer leat (base map © Land Niederösterreich, NÖ Atlas).

Tank	Measurements - distance between the tops of the embankments	Maximum preserved height of the embankments
Mining area 1		
1	80 x 43 m	3.60 m
Mining area 2		
2	40 x 20 m	2.10 m
3	-	-
4	-	-
5	35 x 22 m	2 m
Mining area 3		
6	65 x 30 m	2.20 m
Mining area 4		
7	**-**	**-**
Mining area 5		
8	42 x 22 m	1.50 m
9	45 x 22 m	1.80 m

Table 1: The dimensions of the mining areas and the water tanks.

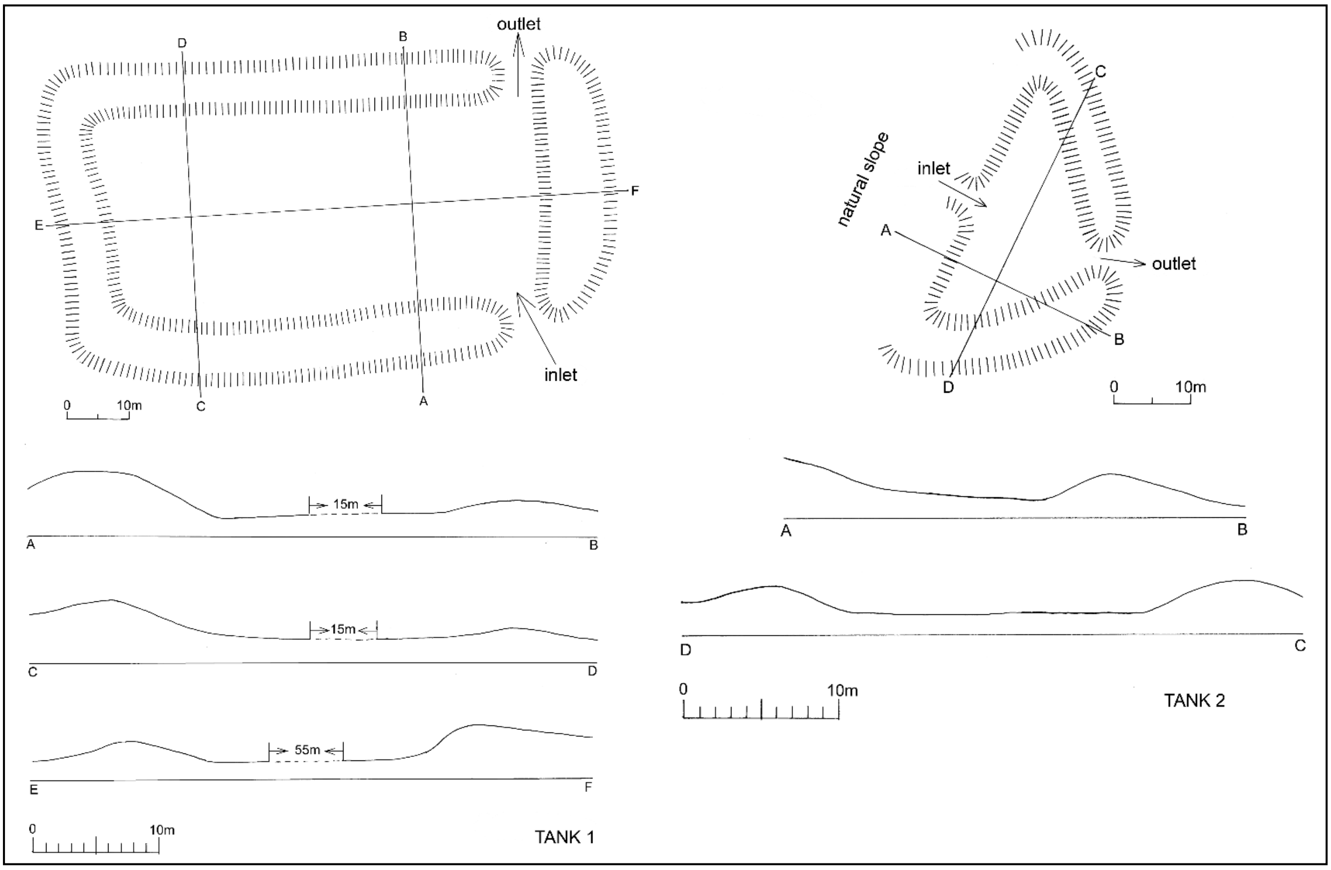

Figure 4: Tanks 1 and 2 showing the profiles of their embankments

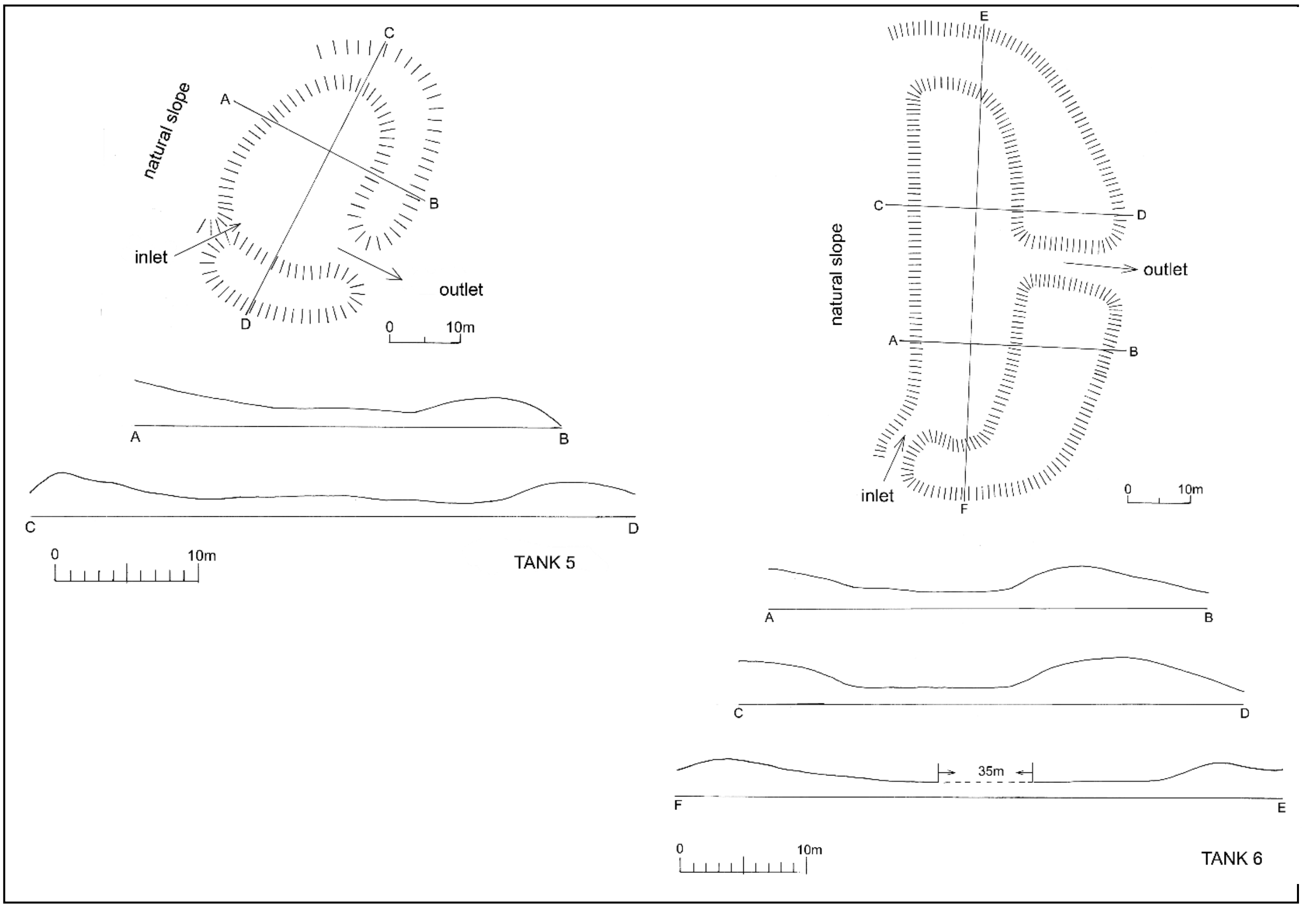

Figure 5: Tanks 5 and 6 showing the profiles of their embankments.

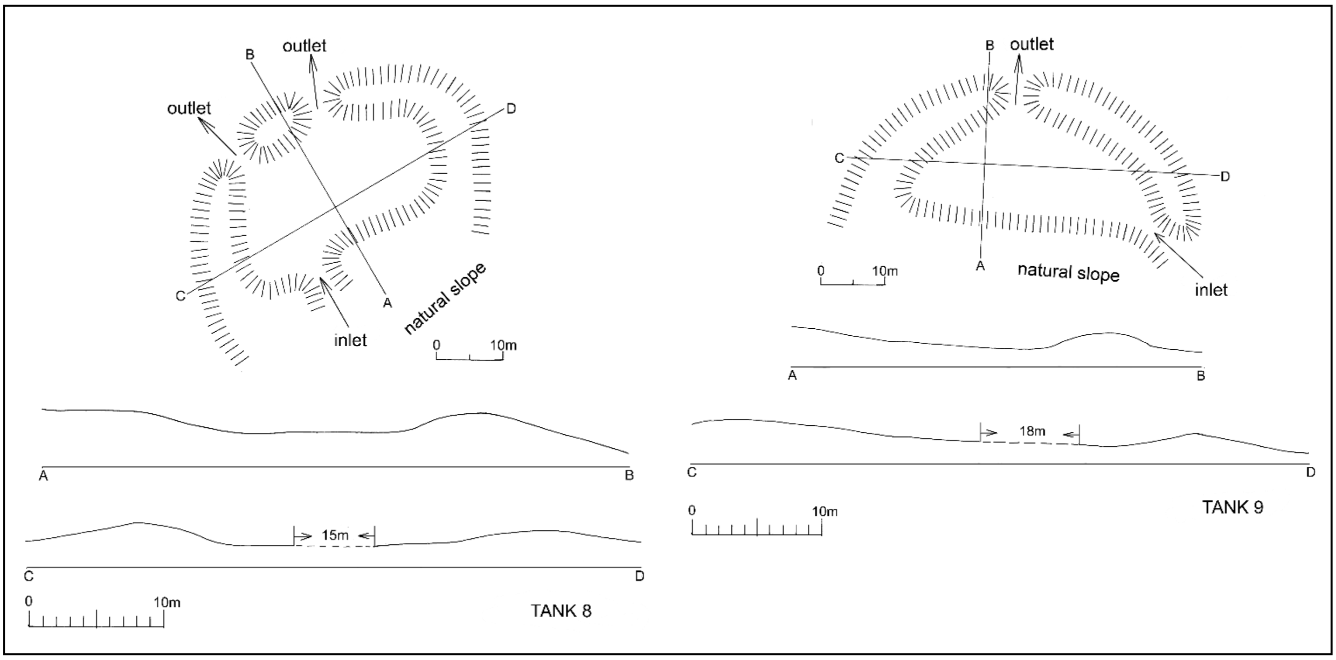

Figure 6: Tanks 8 and 9 showing the profiles of their embankments.

Figure 7: The inside of tank 2 looking north-east.

Figure 8: The outlet from tank 2 looking south-east.

Figure 9: The inlet to tank 5 looking south-west.

Figure 10: The outlet from tank 5 looking south-east.

The leats

As water is scarce on the plateau of the *Karth* long leats were built to collect water from seasonal water courses as well as rainwater and water from melting snow in the spring. The courses of the leats are still clearly visible and some stretches have been reused as forest roads and hiking trails (Fig 11). Since medieval times they were thought to have been ancient roads. They are first mentioned as *gygantea uia* and *Aentiskenwek* in a document of the 12th century. Since the first half of the 16th century they have been called *Entwege*, a term that most probably derives from *Aentiskenwek* (Cech and Kühtreiber 2013, 8-9). In total there seem to have been at least five leats (A-E in Fig 1).

The leats were first described as archaeological features in the 1960s by the archaeologist Johann Danzer (1964-65) who interpreted them as Roman roads despite the fact that they are not part of any wider network of roads and do not connect any settlements; they begin and end in the middle of nowhere. The credit of being of leats in connection with mining belongs to the local historian Georg Reisner (2008). Figure 12 shows the courses of the Schwarzataler and Kirchauer Entweg leats which have both been documented by local historians (Maywald 2007; Reisner 2008; 2012) and Table 2 gives an overview of their lengths and gradients. Reappraisal of these surveys as well as detailed surveys of the other three leats will be part of a future research project.

The *Schwarzataler* leat starts in the so called *Syhrngraben* to the west of the mining district and fed into tank 1 above mining area 1. It meanders through the small valleys formed by seasonal watercourses running parallel to the 550m contour line. The course that is still visible ends about 500m to the west of mining area 1, a little bit higher than tank 1 (Fig 12). In the early 1960s three archaeological trenches were dug through the channel of this leat (Danzer 1964-65, 232-234, fig 106) but unfortunately the exact locations of these trenches were not recorded. Trench I was dug in insignificant. The sections of trenches II and III however show a channel dug into the hillside gravel (Fig 13). The channel in trench II has a V-shaped cross-section and is 1.3m wide with a preserved depth of 0.4m. Trench III shows the channel has a U-shaped section 2.2m wide and a preserved depth of 0.4m. In both cases the excavated material was deposited on the downhill side of the channel to create an artificial bank.

The *Kirchauer* leat begins to the west of the village of *Kirchau* and ends to the east of mining area 1, but 70m below tank 1 at the top of deep gullies. As there is no evidence of a tank at the end of this leat it is either possible that its water was used for continuous flooding of the deposit or that a tank had been destroyed by water coming from Tank 1.

The mean gradient of these two leats are respectively 0.64 and 1.45m/km. This corresponds well with the specifications of the Roman architect Vitruvius who writes that the ideal gradient of aqueducts is between 0.2 and 5m/km (Vitruvius *De architectura* 8. 6.1).

Table 2: Details of the Schwarzataler and Kirchauer leats.

Name of leat	Altitude at the beginning	Altitude at the end	Parallel to	Length	Mean gradient
Schwarzataler	548 m	532 m	550 m contour line	25 km	64 cm/km
Kirchauer	471 m	462 m	470/465 m contour line	6.2 km	1.45 m/km

Note: All figures are approximate

Figure 11: The course of the Schwarzataler leat.

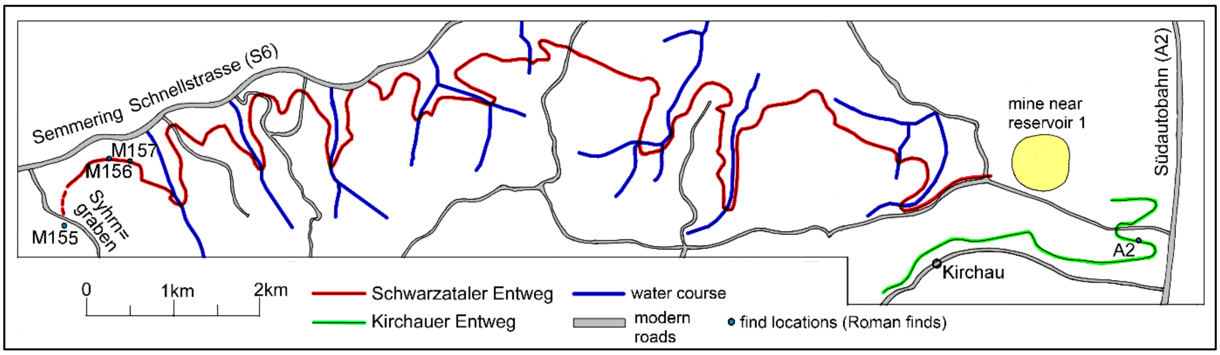

Figure 12: The courses of the Schwarzataler and Kirchauer leats (after Maywald 2007 and Reisner 2012).

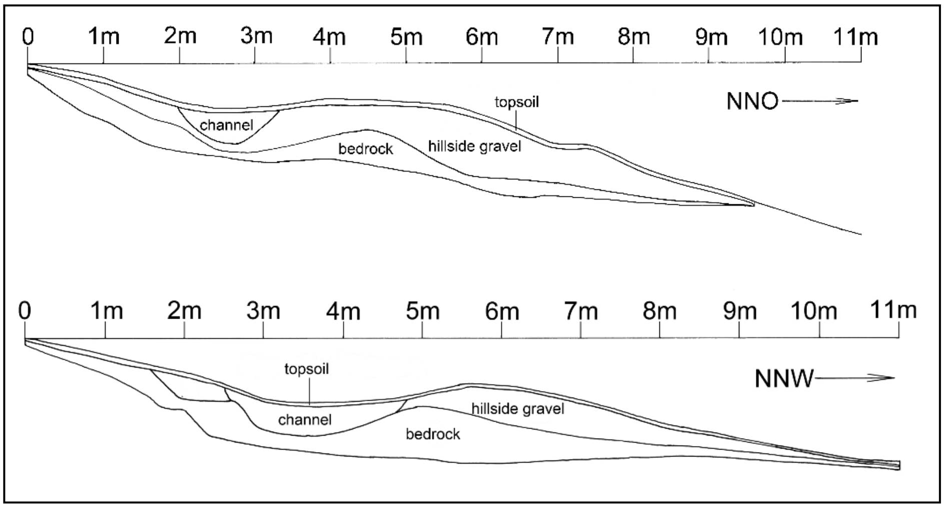

Figure 13: Sections through the Schwarzataler leat (after Danzer 1964-65, fig 106).

The archaeological finds

To the east and to the north of mining area 1 are two artificially levelled terraces 8m by 20m and 100m by 200m respectively (Fig 3, AF 1 and AF 2). Numerous Roman finds now in private collections and local museums were recovered from these terraces, which suggest their interpretation as living and/or working areas for the miners. A catalogue of these, unfortunately unstratified, old finds was published by Reinhard Lang (2010). Apart from a few fibulae, knives and potsherds, numerous tools were found. Some of these tools, which are of special interest in connection with Roman gold mining, are presented here.

Wood working tools

On a mining site such as the one described above numerous tasks have to be done involving special tools for working with wood. The mining area has to be cleared of trees and brushwood before mining can begin and the wooden troughs for the washeries have to be made.

Figure 14 shows examples of wood working tools from the Roman mining district. The woodman's axe (Fig 14.1) is the basic tool for felling trees and splitting logs. The carpenter's tools are a carpenter's broadaxe (Fig 14.2), a draw knife (Fig 14.3), the blade of a plane (Fig 14.4) for trimming beams and planks, a spoon bit (Fig 14.5), a spiral drill (or bodkin ?) (Fig 14.6) and an awl (Fig 14.10) for making holes for nails, a gouge (Fig 14.7) for cutting round holes, different types of chisels (Figs 14.8 and 14.9) and a large pair of compasses (Fig 14.11) for scribing exact lengths and circles as well as for dividing a given length into equal parts.

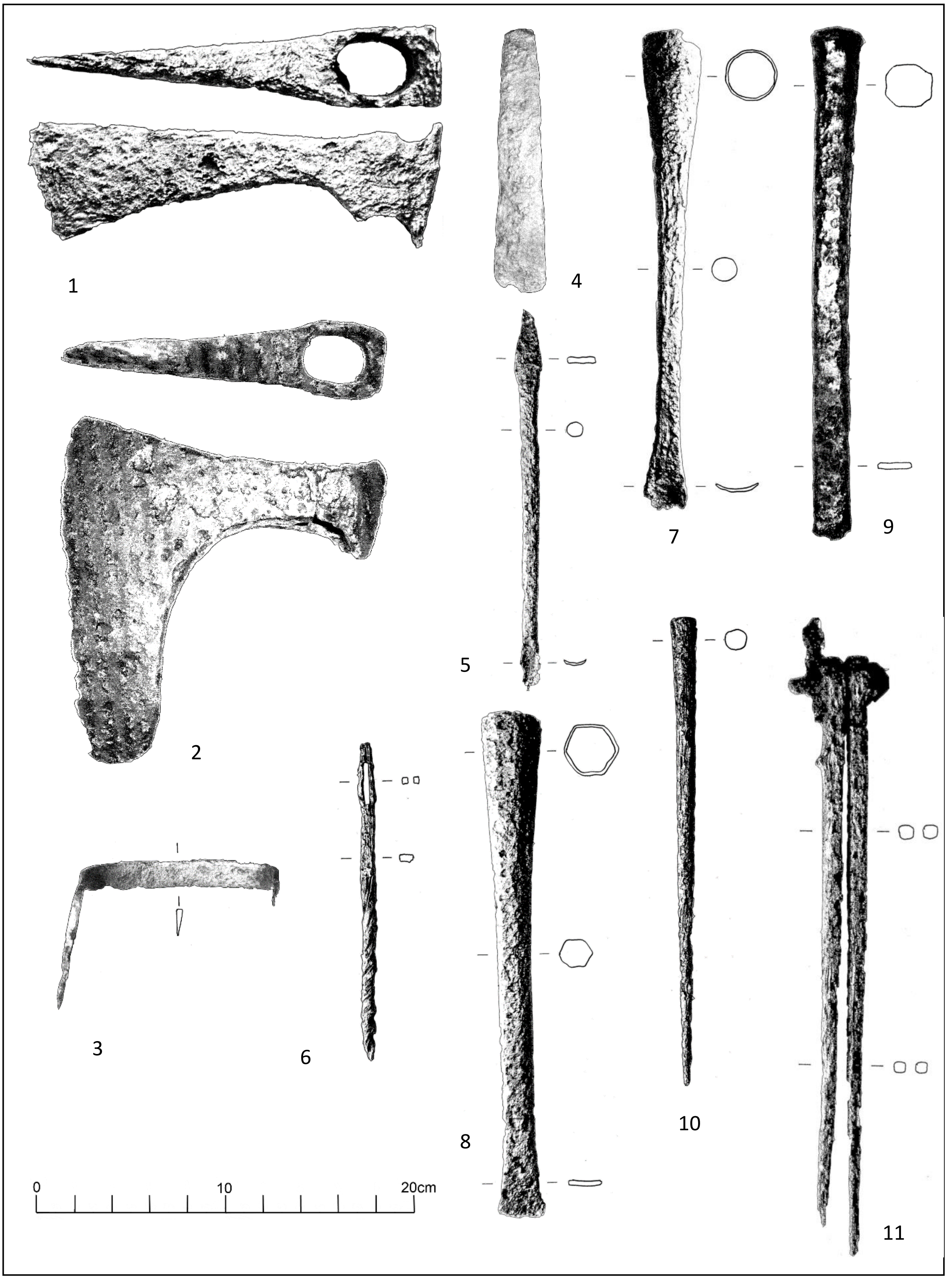

Figure 14: Woodworking tools. 1: woodman's axe, 2: carpenter's axe, 3: draw knife, 4: blade of a plane, 5: spoon bit, 6: spiral drill or bodkin, 7: gouge, 8 and 9: chisels, 10: awl, 11: pair of compasses.

Smithing tools

The blacksmith is one of the most important craftsmen on a mining site. Tools have to be regularly repaired and sharpened and occasionally special tools were made to the miners' specifications. One of the most important finds is a block anvil (Fig 15.1). The other smithing tools are a blacksmith's hammer with a square face and a rectangular cross pein (Fig 15.2), a hammer with two peins (Fig 15.3) that was used for drawing out thick piec

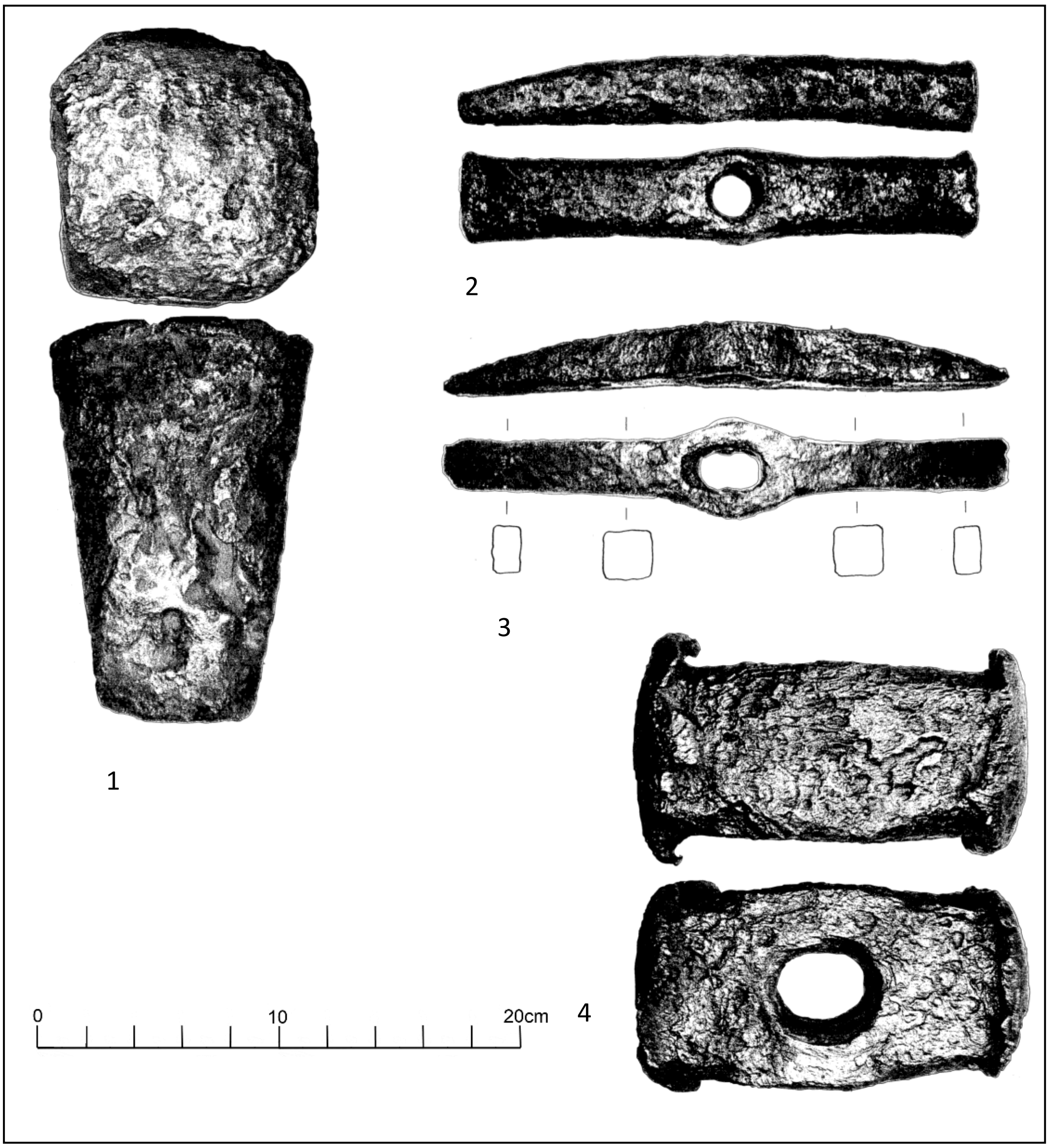

Figure 15: Smithing tools. 1: anvil, 2 and 3: hammers, 4: sledge hammer.

Mining tools

The mining tools can be divided into two groups, picks and hoes. Both types of tools are well known in the archaeological literature as agricultural tools (White 1967; Pohanka 1986; Pollak 2006). They are however multipurpose tools that could be used for a variety of purposes, among them mining.

The picks can be divided into two types. Type 1 (Fig 16.1) has two cutting edges, one perpendicular and the other parallel to the handle. In the Latin sources this multipurpose tool is called a *dolabra*. It was the standard digging tool of the Roman soldier (Bishop and Coulston 2006, 67, 117, 185) which was not only used for digging trenches, but also for pulling down city walls during sieges (Tacitus *Historiae* 3. 20; see also scene 116 on Trajan's column) and in emergencies even as a weapon (Tacitus *Annales* 3. 46). In agriculture it was used for various tasks, like clearing woodland (Columella *De re rustica* 2. 2.28) and breaking up clods of earth after ploughing (Palladius *Agricultura* 2. 3). On a mining site it could have been used for digging the tanks and the leat channels as well as for clearing woodland. One edge can be used like an axe for chopping the roots of trees and the other is perfect for loosening and removing large stones. A pick of this type was found in the Roman lead-silver mine of La Loba in Spain (Domergue 2008, fig 42).

Type 2 picks (Fig 16.2) have a long and narrow blade sharpened to a point. So far no parallels have been found in the archaeological literature. It is quite possible that this type of pick was developed by local miners and produced in a smithy on site. The shape and the massive point suggest that it was used to break up the soil before hydraulic mining.

The hoes can also be divided into two types. Type 1 (Fig 16.3) has a rectangular blade with a slightly splayed edge. In Latin literature they are known as *marra and* were used for spreading fertilizer in vineyards and kitchen gardens (Columella, *De re rustica* 10. 72) and for loosening the soil after ploughing (*ibid* 10. 89; Pliny *Historia Naturalis* 17. 159). A hoe of Type 2 (Fig 16.4) has a long pointed oval blade; in Latin it is called a *sarculum*. It was a multipurpose agricultural tool used for example for spreading fertilizer (Columella *De re rustica* 2. 15.2) and to clean out irrigation channels (Cato *De agricultura* 155). On a gold-mining site hoes could have been used in the washeries, but also for cleaning out the leat channels in the spring and after heavy rains.

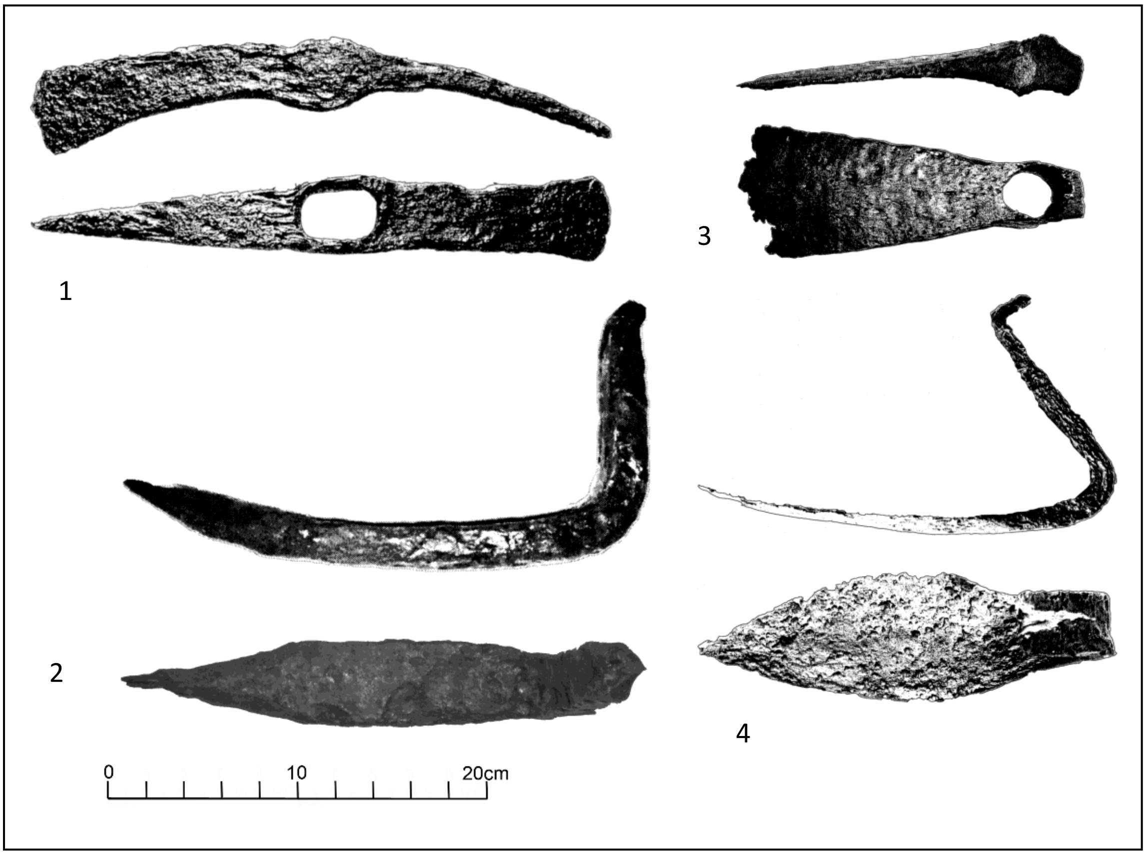

Figure 16: Mining tools. 1: type-1 pick, 2: type-2 pick, 3: type-1 hoe, 4: type-2 hoe.

Crucible tongs and weights

The crucible tongs (Fig 17) can be seen as proof that metal was melted in crucibles, though so far no crucibles have been found. The fact that the tongs were found in the gold mining area suggests that placer gold could have been melted and cast into bars for transportation.

The collection of small lead weights (Fig 18) could have been used to weigh the extracted gold. Table 3 provides details of them. Their actual weight correlates well with Roman weight standards (Wikander 2008, 764, tab 30.3). Small deviations are caused by the inaccuracy of Roman scales and the problems of precise casting. Small holes drilled into weights 6 and 9 however show clearly that an accurate calibration was attempted. There is a marked difference between the actual weight of the pieces and the weight they should have if they were made of pure lead. The analysis with a portable XRF showed that they are made of lead-tin alloys. The percentages of tin in the alloy given in Table 3 are estimates, taken from a table of densities and compositions of lead-tin alloys. Alloying lead for weights with tin makes perfect sense. Lead is a very soft metal and can undergo considerable abrasion. Tin makes the metal harder and the weights truer to their intended weight.

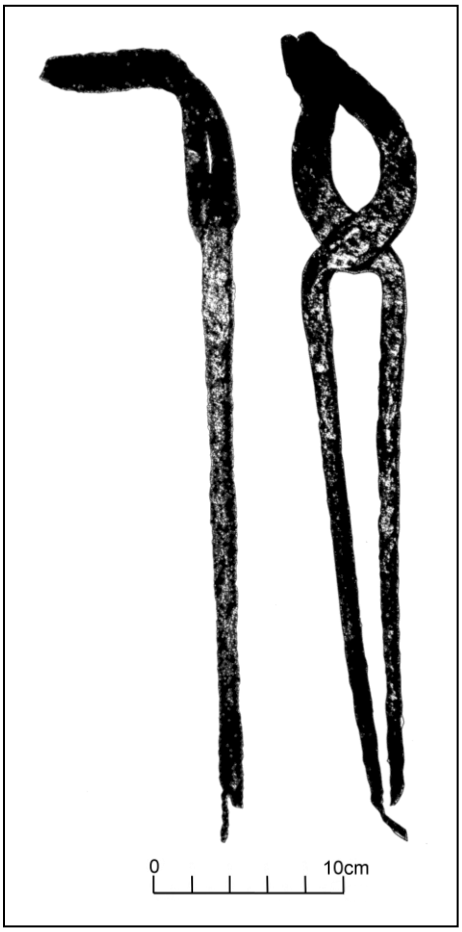

Figure 17: Crucible tongs.

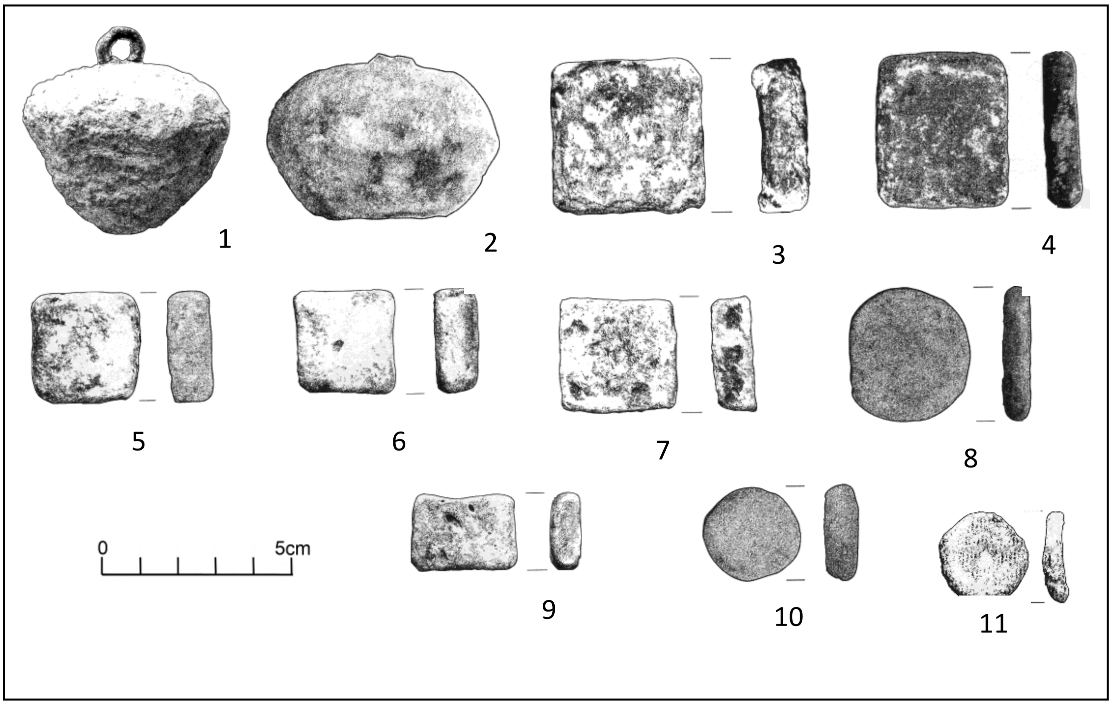

Figure 18: Roman weights.

Table 3: Roman weights from the Karth

Figure	Weight (g)	Roman unit of weight	Volume (cm³)	Weight (g) if pure lead	Density	Pb (%)	Sn (%)
18,1	537	545,76 g: 20 unciae (2 dextantes)	50	567	10,74	84	16
18, 2	520	545,76 g: 20 unciae (2 dextantes)	50	567	10,4	76	24
18, 3	136,6	136,44 g: 5 unciae (quincunx)	14,6	165,56	9,36	49	51
18, 4	123,8	122,79 g: 4 ½ unciae (9 semiunciae)	11,8	133,81	10,49	80	20
18, 5	65,3	68,25 g: 2 ½ unciae (5 semiunciae)	6,5	73,71	10,05	68	32
18, 6	68	68,25 g: 2 ½ unciae (5 semiunciae)	6,6	74,84	10,3	74	26
18, 7	66,5	68,25 g: 2 ½ unciae (5 semiunciae)	7	79,38	9,5	54	46
18, 8	54	54,58 g: 2 unciae (sextans)	5,5	62,37	9,81	61	39
18, 9	41,5	40,93 g: 1 ½ unciae (sescuncia)	4,1	46,49	10,12	69	31
18, 10	30,1	30,68 g: 9 drachmae (drachma: 1/8 uncia)	2,9	32,89	10,39	75	25
18, 11	16,7	17,05 g: 5 drachmae (drachma: 1/8 uncia)	1,8	20,41	9,28	47	53

Miscellaneous finds

Knives, an iron rack for cooking over an open fire, keys and fragments of copper alloy vessels give evidence of a miners' settlement in the vicinity of the mines. A very fine copper alloy balsamarium of the end of the 2nd or first half of the 3rd century decorated with a frieze of *erotes* hints at the presence of a member of the middle or upper levels of provincial society (Drack 2010). The carrying handle of a helmet is proof of a military presence, which is not surprising, given that gold mining was under government control in Roman times (Domergue 1990, 279-280; see also Strabo *Geographica* 4. 6.12).
Apart from tools and objects of daily life numerous coins, including a hoard of 129, were found in the area (Schindel and Lang 2013).

Conclusion and future work

Even though the first survey and the reassessment of the finds clearly demonstrates Roman gold mining in the *Karth* there are numerous questions that need addressing in a future research project. The field survey has to be continued as it is very probable that more tanks are waiting to be found. The courses of the leats have to be properly surveyed and special attention needs to be paid to the distribution of water to the various tanks. So far no detailed survey of the steep water-worked opencasts has been undertaken, and the possible tanks for the washeries need investigating. Archaeological excavations are planned to study the construction of the tanks and the embankments as well as to investigate the probable settlement sites. In conclusion it can be said that the Roman gold mining district on the *Karth* is an exciting site of international importance that merits further studies.

Acknowledgements

I thank my friend and colleague Thomas Kühtreiber (Institut für Realienkunde des Mittelalters und der frühen Neuzeit, Salzburg) for showing me this fascinating and unique area. Marcos Martinón-Torres (Institute of Archaeology, UCL) kindly analysed the Roman weights and supplied me with the table of densities and compositions of lead-tin alloys. I am grateful to the local historian Andrea Nöhrer (Natschbach), who organized a presentation of the Roman mining district in her village, which put us in touch with the local people whose knowledge of the area was indispensable when conducting the survey. Last but not least I want to thank my friends Reinhard Lang (Gloggnitz) and Horst Steurer (Ternitz) for their help with the field survey, as it would have been impossible to carry it out on my own. Figures 1-13 are copyright the author, Figures 14-18 copyright R Lang.

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