Chert of Choice: Raw Material Procurement Strategies in Northeastern Vorarlberg (Austria) during the Boreal and Atlantic – a Case Study

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Abstract: Northern Alpine radiolarite and chert constitute two of the standard raw material varieties in numerous archaeological sites of western Austria from at least the Late Palaeolithic onwards. Although the presence of these raw materials has been recorded time and again in the archaeological record, only few studies have investigated the respective procurement strategies and the decision-making processes behind the exploitation of these ubiquitous lithic resources. Therefore, it is the aim of this paper to explore their utilization in more depth, using the area of northeastern Vorarlberg as a case study. Here, in the regions Großes Walsertal and Kleinwalsertal, several outcrops of the Ruhpolding Formation and thus primary deposits of high-quality radiolarian rocks and chert are present. The usage of these raw materials in archaeological contexts is especially evident in the Kleinwalsertal, where numerous sites, dating from the middle of the Boreal and to the end of the Atlantic period, were documented from the 1980s onwards. These sites contain large quantities of lithic artefacts, predominately made from locally available chert varieties. Thus, the area provides an opportune possibility to examine the different procurement modes of local varieties as a resource for the production of blanks and tools. To understand these strategies, the lithic artefacts were studied in more detail via an analysis of their morpho-technological and taxonomic characteristics as well as their respective position within the *chaîne opératoire*. This revealed interesting differences and similarities between sites from various chronological and topographic contexts, including the choice of raw material sources (primary vs. secondary deposit), colour and the extent of preliminary core curation strategies.

Keywords: Mesolithic, Austrian Alps, radiolarite and chert, Kleinwalsertal, raw material procurement

Introduction

Lithic artefacts in their various forms and shapes constitute the pivotal piece of material culture of the Stone Ages to last into our days. In many cases they represent the only remainder from the people who originally crafted them. As raw material for their production, various famous high-quality sources and varieties of flint and chert can be found all over Europe, such as Baltic flint, chocolate flint and the chert varieties of the Gargano Promontory in Apulia, Monti Lessini and Le Grand Pressigny.

However, for scientists who mainly work in the areas of the Northern Limestone Alps, other 'lower-quality' but none the less important varieties were available, including Flysch quartzite, Northern Alpine chert and – especially – radiolarite.

We know of a usage of these locally available raw materials from the Pleistocene onwards. Pieces made of radiolarite have been found, for example, in the Upper Palaeolithic layers of the southern German sites Henauhof Nordwest,[3] Felsställe[4] and Helga-Abri,[5] as well as in the Late

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[3] Jochim 1993.
[4] Kind 1987.
[5] Hahn – Scheer 1983; Hess 2019.

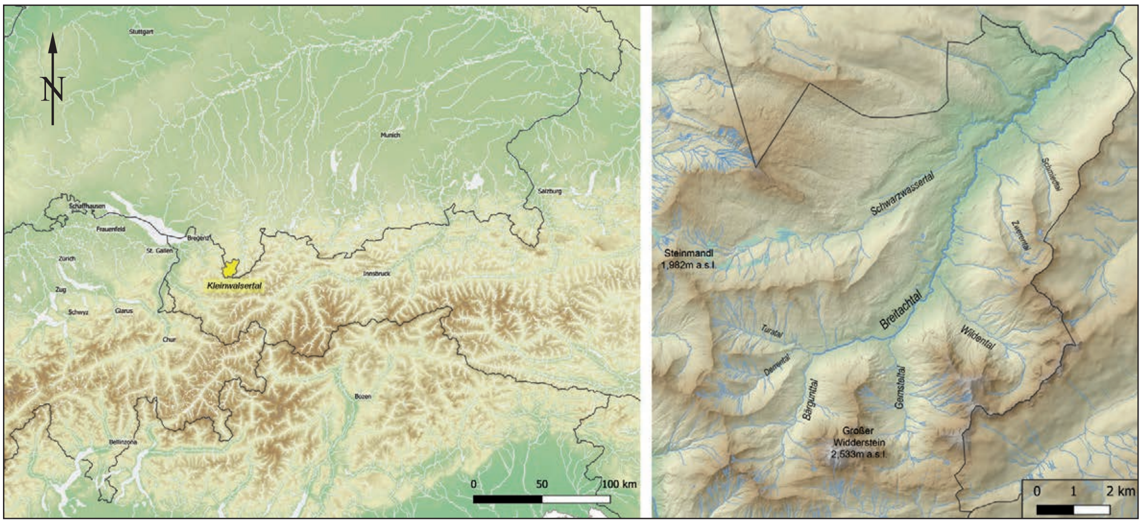

Fig. 1 Kleinwalsertal (after Copernicus – eu_dem_v11_E40N20–25m DEM)

Palaeolithic sites Altwasser-Höhle 1[6] and Unter den Seewänden[7]. During the subsequent Mesolithic, radiolarite becomes one of the staple raw materials in the context of the Northern Alps of western Austria.[8]

However, although these raw materials have been registered repeatedly in the archaeological record, so far, few studies have looked into the respective procurement strategies and the decision-making processes behind the utilization of these ubiquitous lithic resources of western Austria.

Therefore, it is the aim of this paper to explore the usage of these lithic varieties in more depth, using the area of northeastern Vorarlberg as a case study. Here, several outcrops of the Ruhpolding Formation, and with it primary deposits of high-quality radiolarian rock and chert, can be found within the regions Großes Walsertal and Kleinwalsertal.

The Kleinwalsertal proves an especially suitable research area, with its multitude of archaeological sites and lithic artefacts.[9] Therefore, we will focus our attention on this area and on the two largest sites of the region – the rock shelter Schneiderküren and the open-air site Egg-Schwarzwasser. These sites provide an opportune possibility to examine the different varieties of local raw materials available, the respective procurement modes of local varieties, as well as the technological traits in the production of blanks and tools.

Our main questions in this paper will be:

- To what extent were the local varieties used in the sites of the Kleinwalsertal region?
- Is there a choice of raw material and/or colour?
- Which deposits where actually exploited: primary, sub-primary, secondary?
- Can we reconstruct the complete production sequence for all available raw material varieties? And if not, what conclusions can be drawn from this?

[6] Jagher et al. 2000.
[7] Gehlen 2001.
[8] Leitner et al. 2015.
[9] Posch 2020; Posch 2022.

Research Area and History

The Kleinwalsertal at the northeasternmost edge of the province of Vorarlberg is synonymous with the municipality Mittelberg (district of Bregenz) (Fig. 1). It encompasses an area of 96.8 km² and a maximum length of 17 km. The commune is divided into the districts Riezlern, Hirschegg and Baad, as well as the main settlement Mittelberg. In its South, East, and West, the region borders the Bregenz Forest and the municipalities of Egg, Bezau, Schoppernau, Schröcken, and Warth. In its Northeast, the region adjoins the municipality of Oberstdorf (province of Bavaria, Germany). The Kleinwalsertal can only be reached by car via German territory. This is due to the general northbound orientation of the valley and the fact that no modern road was ever built over the passes in the South and West of the valley. The valley reaches from heights between 1000 m asl at its entrance and 2533 m asl at its highest point, the Großer Widderstein peak.

The first lithic artefacts found within the Kleinwalsertal can be credited to Giuseppe Gulisano, who was able to detect as many as 29 Stone Age sites from 1988 to 1995. First typological evaluations of the stone artefacts suggest mainly a Mesolithic to early Neolithic age.[10] Shortly afterwards, Peter Wischbarth undertook his Voralberg-wide survey from 1995 to 1998, where he was able to identify 41 Stone Age sites, five of them within the Kleinwalsertal.[11]

Further discoveries can be credited to Detlef Willand and Karl Keßler and their "Arbeitsgemeinschaft Archäologie Kleinwalsertal" (Archaeological workgroup Kleinwalsertal). Through their cooperation with the Institute of Archaeologies and the HiMAT research centre (History of Mining Activities in the Tyrol and Adjacent Areas), both University of Innsbruck, four sites were excavated from 1998 to 2007: a rock shelter in the Schneiderküren Alpe (1998–2002),[12] the open-air site Egg-Schwarzwasser (2002–2004)[13] and Bäramähder (2005–2006)[14] and the radiolarite mining site Am Feuerstein (2004–2007, 2009)[15]. Furthermore, 15 find-spots were found by Armin Guggenmos since 2007, all in the vicinity of the Widderstein at the southern border of the region.

As of 2023, 15 single find-spots, 14 site clusters and four excavated sites can be noted for the Kleinwalsertal (Fig. 2). They are in turn associated with the prehistoric occupation, mainly attributed to Boreal and Early Atlantic hunter-gatherer-fisher communities (HGF). A notable exception is represented by the radiolarite mining site Am Feuerstein, attributed to the Late Neolithic.[16]

The sites and their artefacts were studied in detail during the research project "The Kleinwalsertal. A Mesolithic Landscape with far reaching contacts" (2016–2020). The project aimed at an analysis of the archaeological landscape Kleinwalsertal, the extent and duration of its occupation, the various patterns of movement through the landscape and the usage of its resources during the Mesolithic.[17]

Locally Available Resources

Geologically speaking, the Kleinwalsertal is part of the Allgäu Alps which are again part of the Northern Limestone Alps. Within the region, five geological sequences can be observed from north to south: the Helvetic nappe, Aroser mélange, Rhenodanubic Flysch, Ultrahelvetic mélange, and Main Dolomite.

10 Gulisano 1995.
11 Wischenbarth 2001.
12 Nutz 1999; Leitner 2003.
13 Spindler 2005; Nowag 2008.
14 Posch – Leitner 2019.
15 Bachnetzer 2017.
16 Posch 2022.
17 Posch 2021.

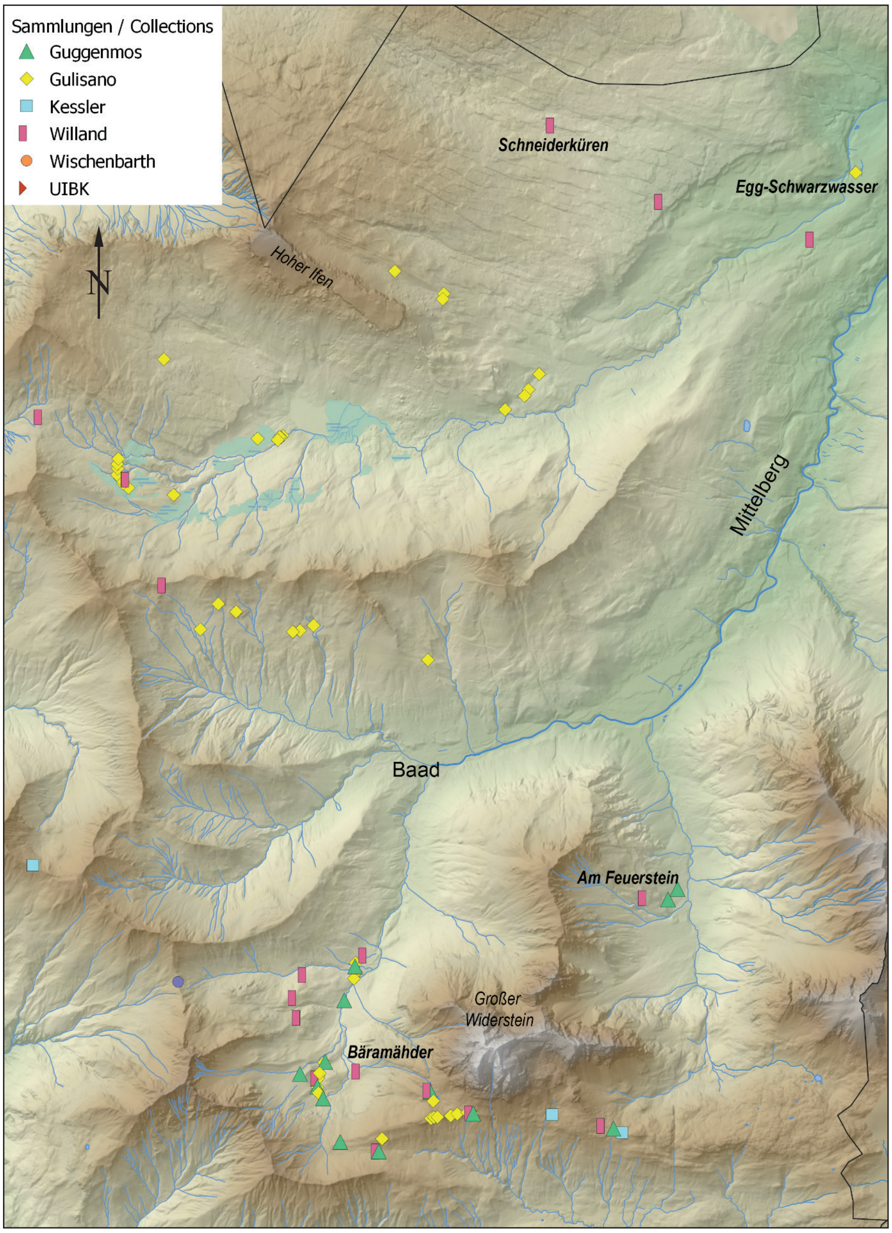

Fig. 2 Location of archaeological sites in Kleinwalsertal including Egg-Schwarzwasser and Schneiderküren (after Posch 2021, fig. 2.5)

Within the southernmost geological unit – the Main Dolomite – layers of the so-called Ruhpolding Formation appear, also containing layers of radiolarite and chert. The formation itself stretches from the Rhine Valley in the west to Vienna in the east (Fig. 3) and is located between the Allgäu and Aptychen layers, forming plates with a thickness of up to 20 cm. Combined, they build formations measuring up to several metres.

Especially on the eastern and western flanks of the Gemsteltal valley, a southern side valley of the Kleinwalsertal, outcrops of this formation can be found in various varieties, different colours and homogeneities. The varieties and their different denominations were classified by Binsteiner and Brandl[18] based on micro- and macroscopic properties. They are defined as follows (Fig. 4):

18 Binsteiner 2008; Brandl 2010; Brandl 2014.

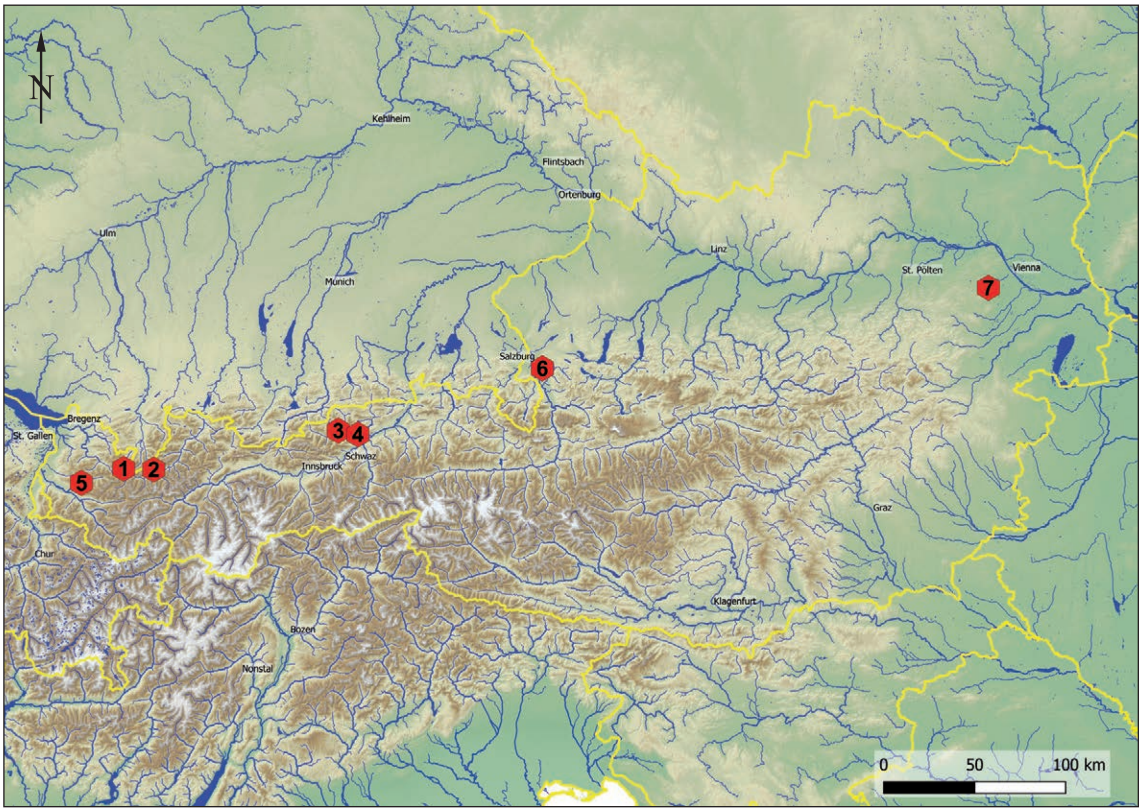

Fig. 3 Archaeologically exploited outcrops of the Ruhpolding Formation in the Northern Alps: 1. Kleinwalsertal; 2. Rothornjoch; 3. Pasillalm; 4. Rofan; 5. Großes Walsertal; 6. Glasenbachklamm; 7 Vienna, including Wien-Mauer and St. Veiter Klippenzone (map is based on: Bachnetzer 2017, Leitner et al. 2015 [after Copernicus – eu_dem_v11_E40N20–25m DEM: Posch 2021, fig. 4.1])

Type T1_1 – black chert or radiolarite with homogeneous texture with middle to fine granularity. Heavy minerals, iron oxides and carbonates appear as non-fossil inclusions. Fossil inclusions include radiolarians in quantities up to 70%, which appear mostly as phantoms. Spicula are seldom. Due to the high proportion of radiolarians, this variety can also be referred to as black radiolarite.

Type T2_1 – bright-red to green radiolarite, with its striking colours, represents the classic radiolarian rock variety of the Kleinwalsertal. The material shows a grained but homogeneous texture with scant fissures and non-fossil inclusions. The proportion of radiolarians lies between 50 and 70%, which are mostly only preserved as phantoms.

Type T2_3 – radiolarite or Walser jasper, a variety much appreciated by collectors, easily recognizable by its typical banding of brick-red and dark-red chalcedony and jasper bands, which are formed through a succession of organic and inorganic inclusions. The texture and granularity of this variety is fine and homogeneous, fissures are rare. The proportion of radiolarians reaches up to 50% with clearly discernible fossils.

Type T2_5 – dark-green to grey-green radiolarite represents the fifth radiolarian rock variety, with a finely grained texture and fissures appearing with a median frequency. Non-fossil inclusions comprise heavy minerals, iron oxides and carbonate; the proportion of radiolarians, which rarely emerge clearly from the matrix and are often only preserved as phantoms, reaches up to 50%.

Type 15_1 – dark-grey to black lydite, which represents grainy and fissured material.

All the above-mentioned types of radiolarite and chert appear locally within primary, sub-primary/residual and secondary deposits in the southern and northeastern parts of the Kleinwalsertal, but do not occur naturally in the northwestern parts of the region.

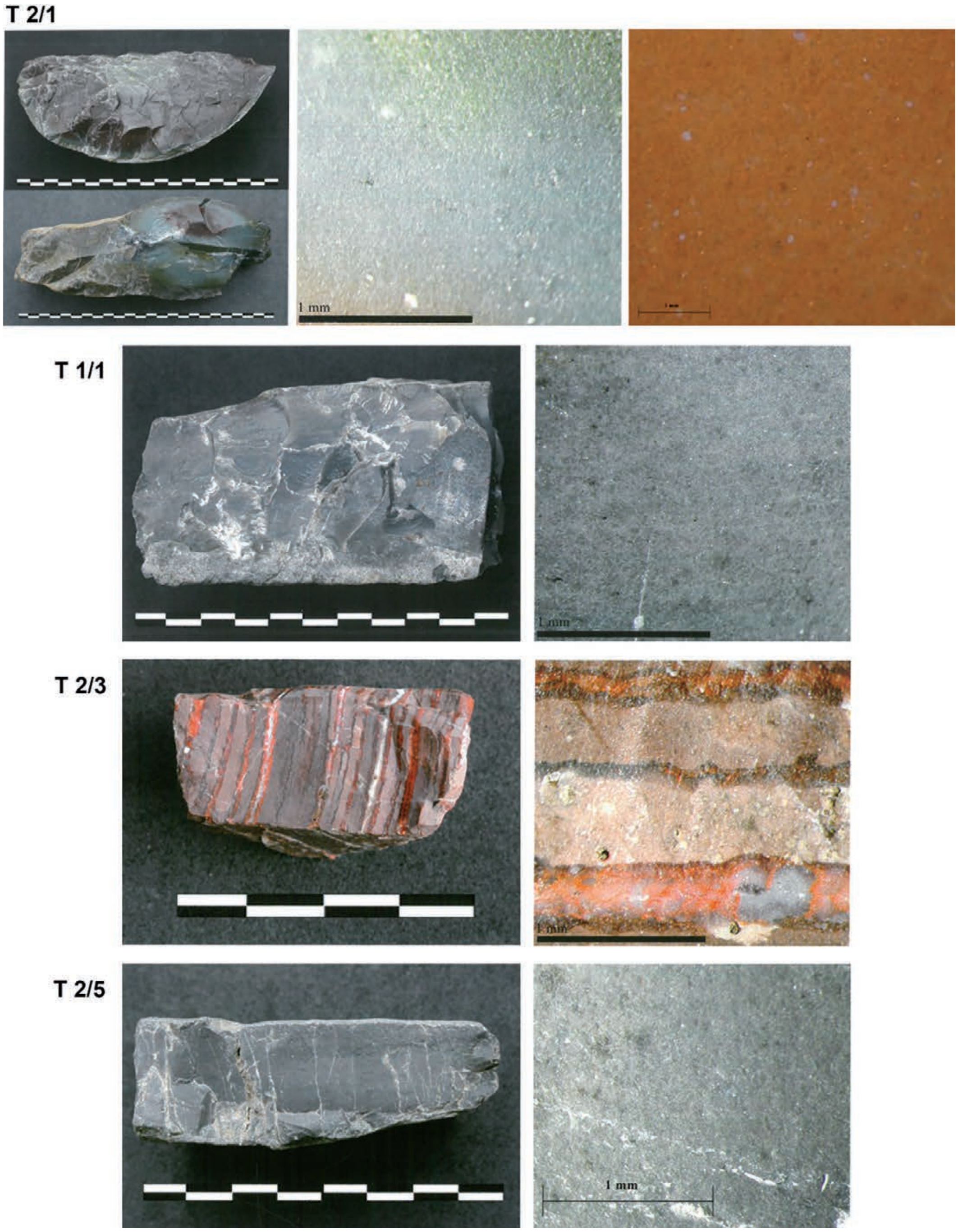

Fig. 4 Radiolarite and chert varieties Kleinwalsertal (after Bachnetzer 2017; Brandl 2019, D142. Abb. 40)

Outcrops of primary radiolarite and chert deposits can be found both in a formation that stretches from the northern flanks of the Große Widderstein to the western flank of the Geißhorn and in layers which pass through the valley from the peaks of the Bärenköpfe all the way up to the peak of the Elfer. The most homogeneous sections are situated on the eastern flanks of the Bärenköpfe at the so-called Feuersteinmähder. Here non-deformed layers with homogeneous radiolarite banks appear, and it is also within this section that the surface mining site Am Feuerstein is located.[19]

[19] Bachnetzer 2017.

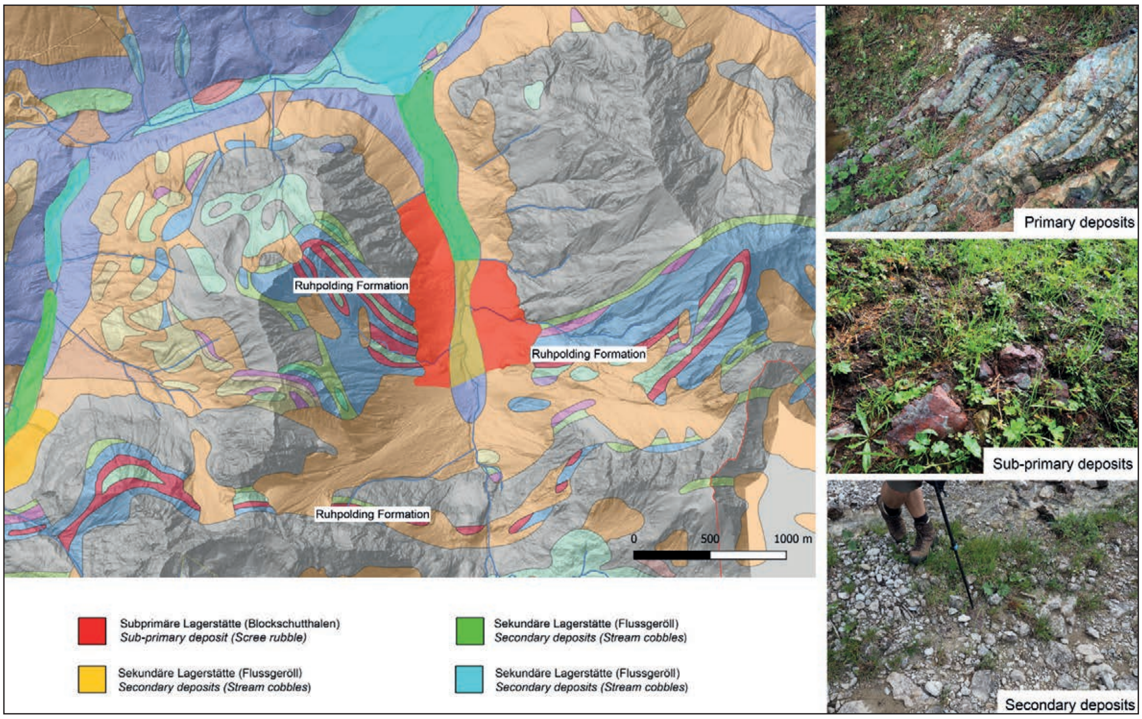

Fig. 5 Primary, sub-primary and secondary/residual radiolarite and chert deposits in the Gemstaltal valley and the adjacent valleys (after Land Vorarlberg – data.vorarlberg.gv.at; ge050_einheiten_epsg4258: Brandl 2010; Bachnetzer 2017; Binsteiner n.d.)

So far, samples of the types T1_1, T2_1 and T2_3 were detected in primary outcrops at the Feuersteinmähder on the western flanks of the Gemsteltal Valley, whereas samples of the varieties T2_5 and T15_1 were as yet collected only on the opposite, eastern side of the valley.

Local residual deposits can be found on the slopes directly above the radiolarian rock and chert layers on both sides of the Gemsteltal valley, whereas secondary deposits in different stages of relocation can be found either in scree deposits – located mainly on the slopes under the primary outcrops of the Gemsteltal valley – or as gravels within moraines or the river beds of the Gemstel River and Breitach River, resulting in a further comminution of the rocks. From here, the raw materials are transported out into the Iller Valley and the Alpine forelands, sometimes over several hundreds of kilometres. Furthermore, smaller and scattered secondary deposits with raw materials of lower quality were also detected on the western slopes of the Bärgunttal valley and the eastern slopes of the Wildental valley (Fig. 5).

However, outcrops of the Ruhpolding Formation including radiolarite are not exclusive to the Kleinwalsertal. Further deposits of interest can be found in the Große Walsertal (Vorarlberg),[20] on the Rothornjoch (Lechtal valley, Tyrol),[21] on the Pasillalm pasture (Karwendel, Tyrol),[22] at the lakes Gurbersee and Grubalacke (Rofan, Tyrol),[23] as well as its easternmost outcrops on the western outskirts of Vienna at the Antonshöhe near Wien-Mauer[24] and along the St. Veiter-Klippenzone[25] (Fig. 3).

[20] Affolter 2002.
[21] Brandl 2014; Leitner et al. 2015; Bachnetzer 2017.
[22] Schäfer 2006.
[23] Brandl 2014; Leitner et al. 2015; Bachnetzer 2017.
[24] Trnka 2014.
[25] Schmitsberger et al. 2019.

Fig. 6 Rock shelter Schneiderküren, seen from the northwest (photo: C. Posch)

Various attempts have been made to differentiate the different raw material varieties of the radiolarian rock outcrops, especially those located in the Northern Alps of western Austria. Mostly these differentiations are based on macroscopic and microscopic properties, including colour, texture, cortex type, the presence or absence of fissures, granularity and microfossil quantity and types.[26] Furthermore, small scale attempts have been made to discern radiolarite varieties through petrological and geochemical means. In a study in 2009, samples were taken from the following deposits: Marulbach and Garsella, Großes Walsertal; Gemsteltal, Kleinwalsertal; Schleimsattel and Juchtenkopf, Karwendel; Grubalacke and Schneidberg, Rofan Mountains; and the Antonshöhe near Wien-Mauer. In addition, two southern Alpine samples from the Val di Non and from the Monti Lessini were examined. The results showed that a geochemical differentiation of the Southern and Northern Alpine varieties is possible. The differences between the different Eastern Alpine radiolarite varieties can be regarded as interesting first results and distinguishing trends. However, the total sample size was deemed too small to be able to make well-founded statements in this regard. Further studies and a larger sample size would be needed to clarify if these observed trends can be seen as clear differentiation markers or not.[27]

Sites and Materials

Within this study, the results of the evaluation of the lithic artefacts of two of the four excavated sites of the Kleinwalsertal – the rock shelter Schneiderküren and the open-air site Egg-Schwarzwasser – will be presented in detail. The two sites are suitable in this regard, since they include the largest assemblages of lithic artefacts in the region. However, they differ in regard to their topographic position in the landscape: Schneiderküren is located at a rock shelter at 1540 m on

[26] Affolter 2002; Brandl 2010; Brandl 2014; Kaiser 2015.
[27] Bechter et al. 2011.

Lab no.	Feature	Quadrant	Relative height	Material	Date BP	Modelled calBC 2σ	Probability %
GrN25812	Charcoal layer, ditch	B 15	98.03	Charcoal	7900 ± 60	7037–6642	95.4
GrN24308	Charcoal layer, ditch	F 15	/	Charcoal	7220 ± 65	6228–5986	95.4
GrN14838	Gravel layer, under drystone wall	E 14	98.23	Bone	6230 ± 40	5306–5054	95.4
GrN24248	Charcoal layer, ditch	F 15	/	Charcoal	3570 ± 40	2030–1773	95.4
GirN25077	Brunt branches, ditch	B 15	98.32	Charcoal	3270 ± 60	1687–1424	95.4
GrN25811	Charcoal layer, under drystone wall	B 14	98.37	Charcoal	3230 ± 30	1541–1425	95.4
GrN20579	Hearth	E 17	98.70	Charcoal	3130 ± 20	1488–1308	95.4
GrN25813	Posthole?	G 14–15	98.42	Charcoal	3030 ± 30	1399–1135	95.4
GrN20578	Pit	C 15	98.35	Charcoal	2050 ± 20	148 calBC – 21 calAD	95.4

Calibration: OxCal v4.4. (Bronk Ramsey 2020); r:5 IntCal13 atmospheric curve (Reimer et.al. 2020)

Tab. 1 ^{14}C analysis Schneiderküren

a subalpine pasture, whereas Egg-Schwarzwasser represents an open-air site and is situated at 1081 m, directly at the valley bottom. Furthermore, the sites differ in terms of the period, with the Egg-Schwarzwasser site dating to the 9th or first half of the 8th millennium BCE and the Schneiderküren site to the turn of the 8th to the 7th millennium BCE (see below). Therefore, we are confronted with two different sites in two different habitats from two different periods.

Rock Shelter Schneiderküren

The rock shelter Schneiderküren is situated in the North of the Kleinwalsertal at 1542 m asl at the present-day forest line on the southern border of the Schneiderküren Alpe pasture. The site can be described as an *abri-sous-roche*, located on the western border of a limestone cliff (Fig. 6). Being located within the Helvetic nappe, its surrounding area is karstic and dry, with scarce water sources, only to be found in places where patches of watertight glauconitic sandstone or greensand occur. One of these patches can be found 10 m below the rock-shelter, where water is collected in a small pond.[28]

The site was discovered by D. Willand in 1998. After contacting the University of Innsbruck, excavations were conducted by Walter Leitner from 1998 to 2002, during which time, an area of 66 m² was examined. While excavating, the long and persistent usage history of the site became evident. Structures like a drystone wall, three hearths, three postholes and a pit filled with charcoal were documented and could be dated from the Middle Bronze Age to the Late Iron Age through the available ^{14}C dates (Tab. 1). Furthermore, traces of occupation activities from the late Boreal and early Atlantic biozones were found at the southern border of the excavation area. These occupations became evident through a calcified bone fragment found under the Bronze Age drystone wall – which could be dated to the end of the 6th millennium BC (GrN14838: 6230 ± 40 BP) – on the one hand, and on the other hand, through a succession of several thin charcoal

28 Posch 2020.

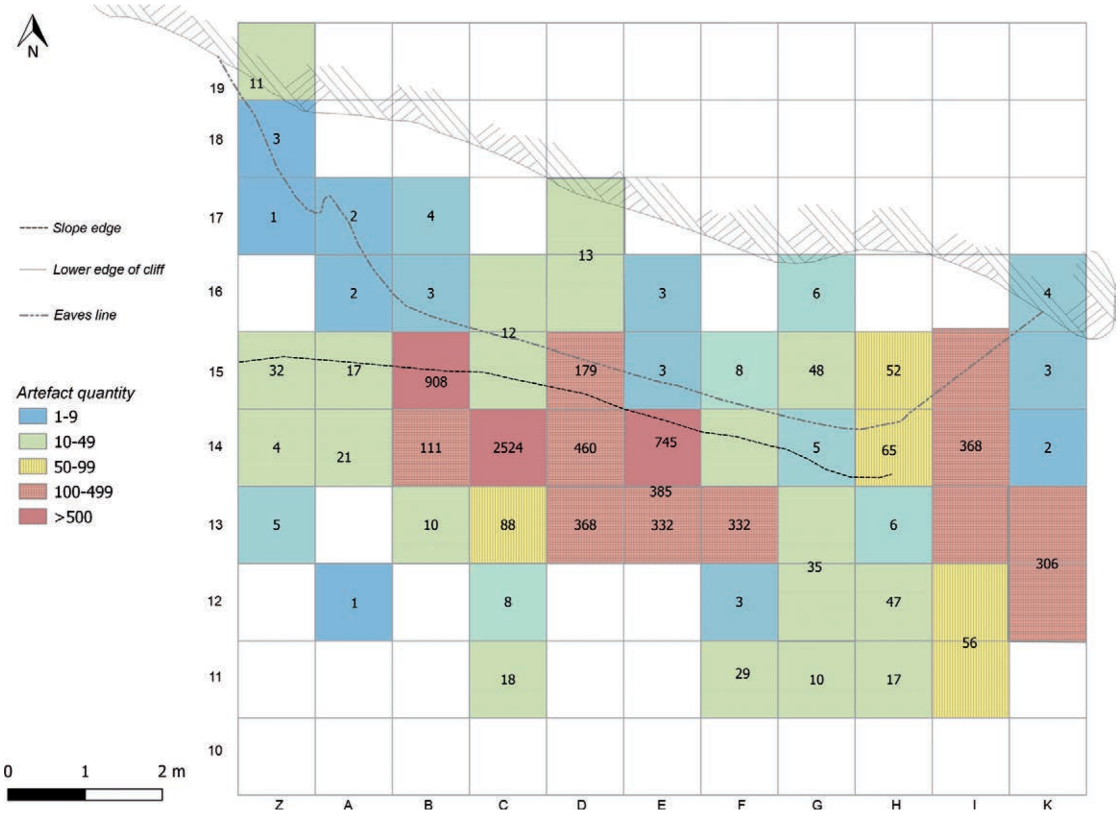

Fig. 7 Artefact distributions at the excavation area Schneiderküren. The microliths concentrated mainly in B-F 13-15 in the area of a shallow ditch, filled with 30 cm of charcoal layers (Posch 2021, fig. 7.24)

Schneiderküren		N	%
Diagnostic pieces	Flake	962	35.8
	Blade	678	25.2
	Debris	749	27.9
	Chip (>10 mm)	85	3.2
	Core	54	2
	Blank indet.	147	5.4
	Total	2675	99.5
Not taken into account	No flint artefact	5	0.2
	Indet.	7	0.3
	Total	2687	100.00
	Chip (<10 mm)	4562	
Total lithic artefacts (analysed)		7249	
Thereof	Preparation	21	0.8
Thereof modified	Modified flake	172	6.4
	Modified blade	66	2.5
	Modified preparation	1	
	Blank indet. (modified)	147	5.5
	Modified core	6	0.2
	Modified debris	20	0.8
	Total (modified)	412	
Tool rate (diagnostic pieces)			15.5
Tool rate (total)			5.6

Tab. 2 Lithic assemblage Schneiderküren

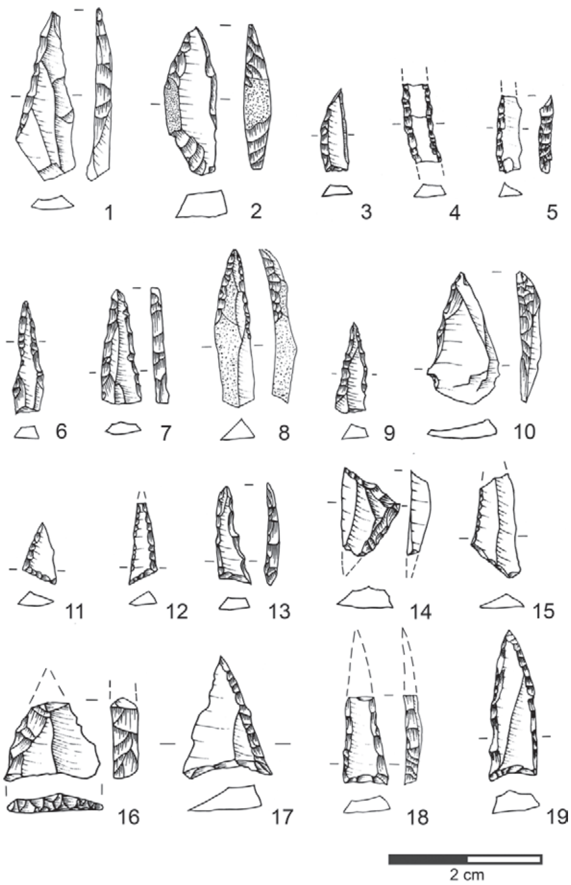

Fig. 8 Microlith assemblage Schneiderküren (selection): 1. truncated micro-point; 2–3. crescents; 4–5. backed bladelets; 6–8. meches de fôret; 9–10. micro-points; 11–15. scalene triangles; 16–19. micro-points with base retouch (drawings: B. Nutz)

layers preserved in a shallow ditch under and south of the drystone wall, assignable to a late Early Mesolithic (GrN25812: 7900 ± 60 BP) lowest and a Late Mesolithic (GrN24308: 7220 ± 65 BP) highest point of the sequence.[29]

Another aspect of great importance at the Schneiderküren site is the multitude of more than 7000 lithic artefacts, concentrated in the southern quadrants of the excavation area (see Fig. 7). The lithic ensemble contains cores, debris, flakes, blades, micro-burins and tools, such as scrapers, borers and burins, as well as over 100 microliths (see Tab. 2). They can be classified as baked bladelets, points with concave and convex bases, segments, *mèches de forets* and scalene triangles. Through the high proportions of baked bladelets, micro-points with a concave base and extreme scalene triangles, a typological assignment to the late Early Mesolithic or Beuronian C seems to be appropriate (Fig. 8). This would also correlate with the oldest ^{14}C date obtained from the site. However, a Late Mesolithic to Early Neolithic presence within the assemblage can also be expected, but due to the difficult stratigraphy and prehistoric disturbances, a clear affiliation of lithic artefacts to these younger occupation periods is not possible.[30]

Open-air Site Egg-Schwarzwasser

The open-air site Egg-Schwarzwasser[31] was found by G. Gulisano in the late 1980s in a meadow near the district Egg (Fig. 9). The terrain of the meadow gradually slopes down towards the Schwarzwasserbach River, where the otherwise very narrow and canyon like stretch of the river opens up to a small ford. The site is situated on a postglacial gravel terrace at 1081 m asl on a flat hill at the western side of the meadow. Around a small barn, which was initially built on top of the hill in the late 19th century, various flint artefacts were collected superficially.

Subsequently, excavations took place from 2002 to 2004, conducted by the University of Innsbruck.[32]

During the excavation, an area of 130 m² was examined, with several trenches around the barn at the centre of the hill and about 12 m to the east of the barn, as well as three smaller trenches further west. Unfortunately, no prehistoric structures were found within the sections. This is most likely due to the construction of the barn, the subsequent agricultural use of the meadow and a

[29] Posch 2022.
[30] Posch 2021; Posch 2022.
[31] At first the site was named as find-spot SCHB.17 (Gulisano 1995); only later was it renamed Egg-Schwarzwasser, and for the sake of clarity, the author will only use the latter.
[32] Nowag 2008.

Fig. 9 Open-air site Egg-Schwarzwasser, seen from the southeast (photo: C. Posch)

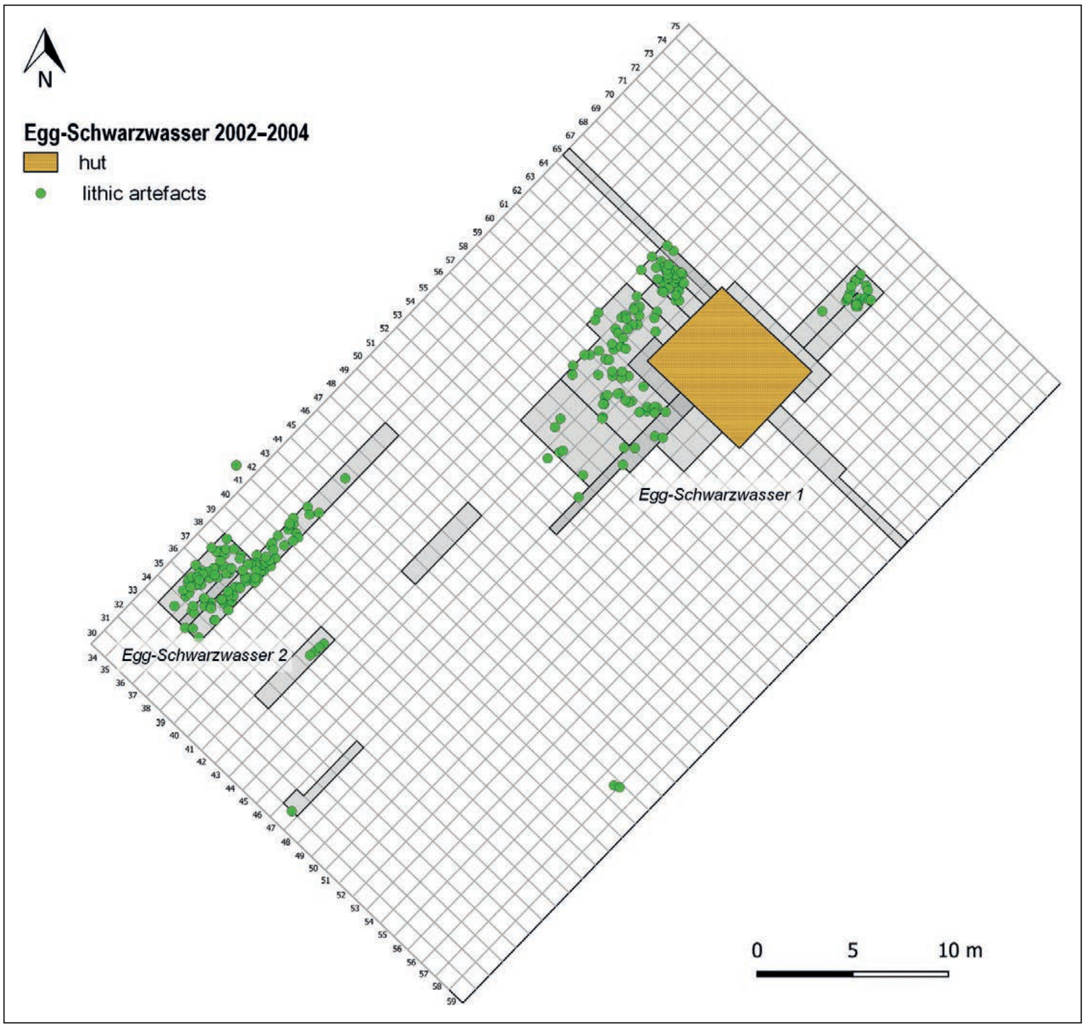

Fig. 10 Artefact clusters Egg-Schwarzwasser 1 and 2 (Posch 2021, fig. 8.7)

Egg-Schwarzwasser									
	Blanks	N Total	%	Egg 1	%	Egg 2	%	Egg Stray finds	%
Diagnostic pieces	Flake	950	37.4	489	35.4	331	38.4	130	43.8
	Blade	707	27.9	390	28.2	249	28.9	68	22.9
	Debris	770	30.3	440	31.8	250	29.0	80	26.9
	Chip (>10 mm)	17	0.7	9	0.7	1	0.1	7	2.4
	Core	47	1.8	32	2.4	13	1.5	2	0.7
	Blank indet.	24	0.9	5	0.4	15	1.7	4	1.3
	Total	2515	99.00	1365	98.90	859	99.60	291	98.00
Not taken into account	No flint artefact	12	0.4	10	0.7	1	0.1	1	0.3
	Indet.	14	0.6	5	0.4	3	0.3	5	1.7
	Total	2541	100.00	1380	100.00	863	100.00	297	100.00
	Chip (<10 mm)	629		348		281		0	
Total lithic artefacts (analysed)		3170		1728		1144		297	
Thereof	Preparation	24		8		9		7	
Thereof modified	Modified flake	90	38.8	46	35.4	32	42.1	12	48
	Modified blade	98	42.2	66	50.7	25	32.9	7	28
	Blank indet. (modified)	37	15.9	13	10	18	22.4	6	24
	Modified core	5	2.2	4	3.1	1	1.3	0	0
	Modified debris	2	0.9	1	0.8	1	1.3	0	0
	Total	232	100.00	130	100.00	77	100.00	25	100.00
Tool rate (diagnostic pieces)			9.2	9.5		9		8.6	
Tool rate (total)			7.3	7.5		6.7		8.4	

Tab. 3 Lithic assemblage Egg-Schwarzwasser

modern rubbish pit, dating to the first half of the 20th century, which in addition to pottery and glass fragments, contained the skeleton of an entire cow.[33] It is conceivable that the archaeological layers on and around the hill were heavily disturbed by these subsequent activities. Also, no datable charcoal sample was found within the various sections.

However, it was possible to find over 3000 lithic artefacts during the excavation process, and although these objects can no longer be regarded as in situ, they nevertheless represent the second largest lithic assemblage in the region, which is worth analysing, albeit with the restrictions imposed on the material by its find circumstances.

The current data obtained during the excavations and subsequent superficial collections suggest that the Egg-Schwarzwasser site can be divided into two main artefact concentrations: one located directly on top of the small hill, now disturbed and relocated through the construction of the barn – Egg-Schwarzwasser 1 – and one about ten metres due southwest at the bottom of the hill – Egg-Schwarzwasser 2 (Fig. 10).

Within the accumulation of Egg-Schwarzwasser 1, 1380 artefacts were found. The concentration is located in the northwestern area of the knoll, gradually diminishing due south. The accumulation Egg-Schwarzwasser 2 is located west of the small barn and comprises 863 objects. It stretches towards the southeast, thinning out towards the south. This concentration has been heavily disturbed and relocated by the large modern waste pit. Additionally, 296 stray finds have been found during the excavation campaigns, scattered within the area of interest (Tab. 3).

33 Spindler 2005.

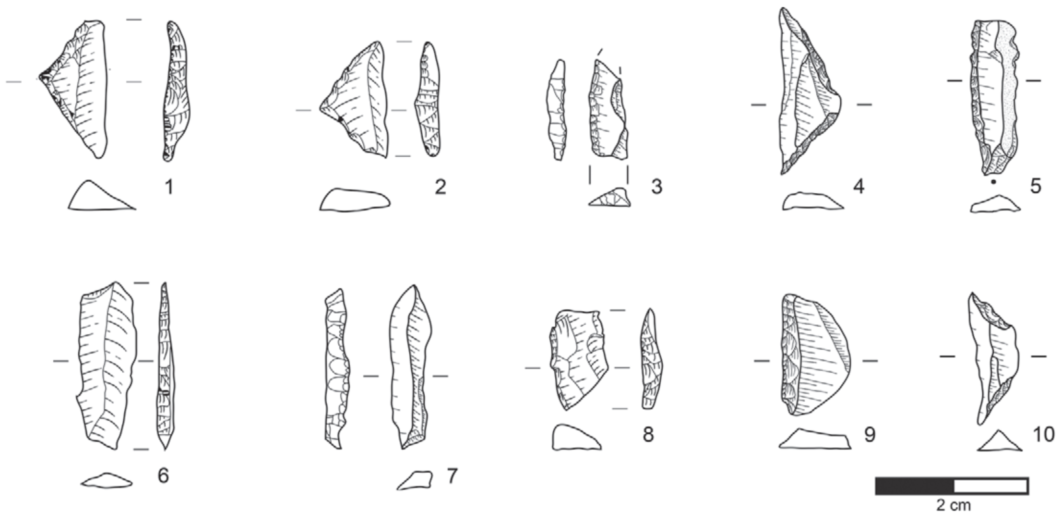

Fig. 11 Microlith assemblage Egg-Schwarzwasser (selection) (drawings: J. Haas [1–2, 6, 8]; C. Posch [3–5, 7, 9–10])

Both concentrations include cores, debris, micro-burins, blades and flakes, as well as tools, such as burins and scrapers, and 14 microliths. The rather small microlith ensemble comprises of isosceles triangles, baked bladelets and points (Fig. 11). Typologically speaking, it would put the ensemble roughly into the Early Mesolithic of the Beuronian A/B. A more accurate dating of the site is impossible at present because of the disturbed nature of the stratigraphy of the camp and due to the lack of datable samples for ^{14}C analysis.[34]

Methodological Approach

The lithic assemblages of the Schneiderküren and Egg-Schwarzwasser sites were analysed by a methodological approach in three parts, which included i) raw material analysis; ii) taxonomic/typological analysis; and iii) morpho-technological analysis.

i) Raw material analysis of the lithic assemblages was one of the key factors in order to determine the quantity of local and non-local raw materials in the respective sites. For these analyses, the assemblages of the sites Schneiderküren and Egg-Schwarzwasser were divided into raw material units (RMG), based on macroscopic aspects and traits, such as the colour, texture and nature of the cortex. From these groups, between one and five specimens per group were selected as samples for microscopic single artefact analysis.[35]

ii) A study of the possible taxonomic affiliation of the two assemblages was mainly undertaken via an analysis of the microliths of the respective sites. This proved to be complex, since both the research area and the Northern Alps of western Austria are situated between the two main Mesolithic typological systems of southern Central Europe: the Beuronian of southwestern Germany and northern Switzerland[36] and the Sauveterrian, found in the assemblages of northern Italy, southeastern France and western Switzerland[37]. These typological groups are similar in various respects, but there are also interesting differences to do with the appearance or absence of certain

[34] Posch 2022.
[35] The extensive results of these studies have already been published in Posch 2021 and Posch – Brandl in press.
[36] Taute 1971; Heinen 2005; Nielsen 2009.
[37] Wyss 1968; Rozoy 1971; Broglio – Kozlowski 1984; Barbaza 1991; Nielsen 2009; Visentin 2018.

forms in the respective regions.[38] The results of these typological analyses have already been published elsewhere.[39]

iii) Furthermore, a so-called feature or attribute analysis was conducted. This method has been used in addition to a typological analysis since the middle of the 1960s and as standard practice since the 1970s. It aims at a holistic description of artefacts to describe lithic artefacts in the most objective manner possible, describing knapping and fracture marks on the distal, proximal, ventral and dorsal sides of the object. Subsequently, the data generated during these studies can be used to understand and reconstruct the various techniques which were applied to produce these objects. Although attribute analysis is not without, at times justified, criticism,[40] it is still a useful tool to create a basis for comparisons with other lithic assemblages based on quantitative and metric data. This is especially important for regions such as western Austria, where analyses of this kind have only been randomly applied and basic data is still largely lacking.[41] During the analysis, and in order to enable user-friendly data entry during the actual data collection, a database was created in which all information on the objects was noted and managed. The attribute database included technological, functional and shaping characteristics, which were recorded according to specified parameters based on the works of several authors north and south of the Alps.[42] For the analysis itself, only diagnostic pieces with measurements over 10 mm were included; objects smaller than 10 mm were only examined with regard to their weight, colour and, if possible, raw material variety. In the case of the studied sites Schneiderküren and Egg-Schwarwasser, 2675 and 2515 objects were analysed as diagnostic pieces larger than 10 mm. Afterwards the obtained data was numerically coded and evaluated using the SPSS26 program.

Furthermore, to garner an understanding regarding the various *chaînes opératoires*[43] in the respective sites, the position of each object was assigned to their respective phases of the reduction sequence: raw material procurement (phase 0), decortification and primary preparation (phase 1), basic blank production (phase 2), tool production (phase 3), tool use (phase 4) and discard (phase 5).[44]

Unfortunately, in this context, limitational factors regarding Schneiderküren and Egg-Schwarzwasser need to be mentioned. Normally, an allocation of a lithic artefact to a stage in the production sequence is achieved by refitting the object into its original position in the sequence. However, this was not done in the case of the Schneiderküren site, nor at the Egg-Schwarzwasser site due to the following reasons:

In the case of Schneiderküren, at least three different occupational horizons can be expected according to the available radiocarbon and AMS dates, but these horizons cannot be reconstructed within the lithic assemblage due to the unclear stratigraphy of the archaeological layers in this section of the trench as well as the excavation technique used and the documentation. The find inventory is structured based on the excavation units of so-called situations, representing artificial spits; however, their depth is seldom recorded, and different numbers of spits were often applied in two adjoining quadrants. Furthermore, relative heights for the find positions were only recorded for about 10% of the lithic artefacts. All these aspects subsequently hinder an accurate assignment of the lithic artefacts to a layer or even secure vertical position within the stratigraphic sequence, let alone an assignment to a respective occupational horizon. Therefore, only a very general vertical

38 Barbaza – Valdeyron 1991; Valdeyron 2008; Heinen 2012a; Visentin 2018.

39 Posch 2022; Posch – Brandl in press.

40 Hartz 1999; Haßmann 2000; Cziesla 2016.

41 Posch 2021.

42 Barrière et al. 1969; Barrière et al. 1972; Auffermann et al. 1990; Galiberti 1990; Hahn 1993; Inizan et al. 1999; Richter 2017.

43 As defined by Leroi-Gourhan 1988.

44 Hahn 2005, 74; Kind 2003, 80: In his model, Kind again refers to those of Geneste and Kieselbach, both of which, however, are unpublished theses.

and horizontal positioning is possible and horizontally only possible with an accuracy of one metre at best. Furthermore, since situations, by which the quadrants were excavated, do not equal a layer or stratigraphic unit, it is rather difficult to situate the respective situations in a meaningful context with other quadrants and their artefacts. All these aspects led to the decision to examine the lithic assemblage of the site Schneiderküren as a whole, since a connection or affiliation to stratigraphic units and layers cannot be assigned with certainty.

In the case of Egg-Schwarzwasser, the situation is even more complex, since we have to assume that none of the lithic artefacts from the two main scatters Egg-Schwarzwasser 1 and 2 can be considered as in situ.

Subsequently, due to these impediments and also due to reasons relating to economy of time during the project, a decision was made against the actual refitting process, as has also been done in similar instances.[45] The allocation of the stone artefacts to the corresponding phases within the *chaîne opératoire* is therefore based on the morphological assignation of the respective objects. It must be emphasized, however, that the unambiguous allocation of an artefact to a certain stage of the *chaîne opératoire* is only truly possible after a refitting of the original production sequence.[46] Since this was not possible in the case of these sites, the results of the analyses presented here must be regarded as statistical guidelines, based on the purely morphological affiliation of the artefacts.

Results

During analysis, 7249 lithic objects were studied from the rock-shelter Schneiderküren, of which 2675 were classified as diagnostic specimens (Tab. 2).

The results from the provenance analysis showed that the assemblage of the rock shelter Schneiderküren contains eight RMG (Fig. 12). These units can be divided into raw material varieties of local (distance from site <25 km), regional (distance from site 25–150 km) and exogenous (distance from site >150 km) origin (Tab. 4).[47]

The lithic artefacts from the Schneiderküren site were mainly made from local raw materials assignable to the varieties RMG 1 to 3, with a strong dominance of the red variety RMG 1 (68%)[48], followed by the olive-green RMG 2 (14%) and respectively lower quantities of the grey-blue variety RMG 1 (3%). Furthermore, chert varieties attributable to a regional context are represented by varieties RMG 4 (11.06%) originating from the Northern Alpine chert breccia, as well as small quantities of radiolarian rock (RMG 5 – 0.6%) not originating from the local deposits within the Gemsteltal valley and spiculite (RMG 12 – two pieces). Next to the local and regional varieties, a small percentage of the lithic assemblage (<2%) was assigned to raw material varieties of exogenous origin: on the one hand, a brown to orange variety of chert (RMG 6), most likely originating from the area around Baiersdorf, and on the other hand, a beige to white variety with coarse, big inclusions (RMG 7), assignable to the chert deposits around Ortenburg.[49]

In relation to the reduction sequence (Tab. 5) of the various raw material varieties of the of the entire lithic assemblage of the Schneiderküren site, it became evident that the sequence of the local or regional varieties RMG 1 to 5 can be reconstructed almost completely. In terms of each variety, cortical flakes and blades of phase 1 as well as blanks and cores of phase 2 are found. Within phase 1, the raw material variety RMG 5 represents an exception, since it is only represented by two cortical blades. Yet this can be attributed to the generally low frequency of artefacts

45 Kind 2003.
46 Hahn 1993, 74; Kind 2003, 80.
47 Richter 2017.
48 Percentages diagnostic pieces >10mm.
49 Posch – Brandl in press.

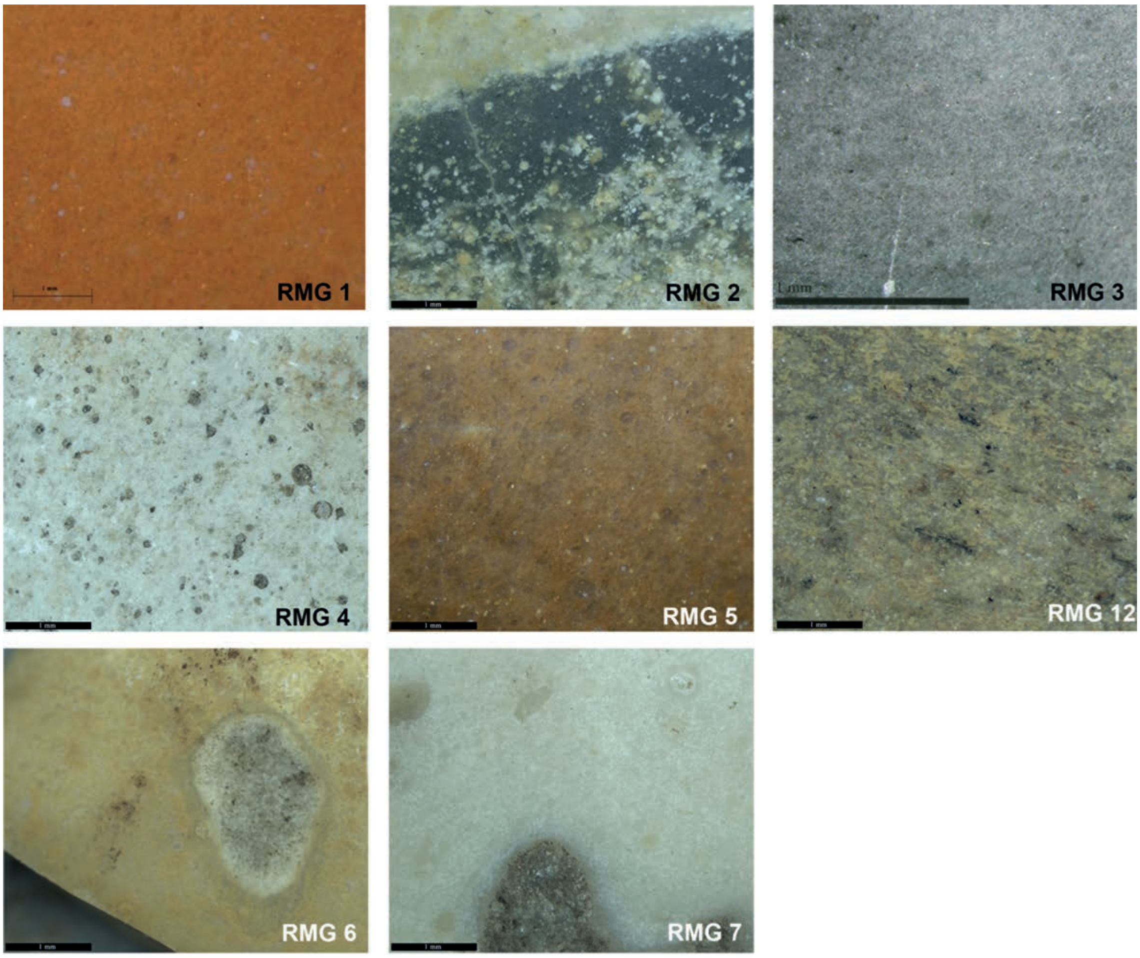

Fig. 12 Raw material varieties Schneiderküren (photos: M. Brandl; RMG 1 after Brandl 2019, D142, Abb. 40)

from this variety. The regional variety RMG 12, spiculite, is only represented by two pieces in the whole ensemble, belonging to phase 2.

In general, objects from the initial production phase are less represented in the reduction sequence than those from phase 2. In RMG 1 they represent 183 pieces or 10% of the diagnostic assemblage. This trend continues in the other local and regional RMG. Furthermore, primary preparations are only detectable for RMG 1 and 4, and secondary preparations only for RMG 1 and 2. This suggests that the exploitation technique used was rather opportunistic, without specific preparation of the core sides or striking platforms. The fact that a relatively large percentage of the cores still show remnants of cortex covering suggests further that there was no complete decortification. It can rather be assumed that after an initial testing, further decortification activities were abandoned, and instead, the production of blanks commenced directly. For phase 3, only a few pieces could be identified by a purely morphological examination. Within the whole assemblage, a total of ten micro-burins and three burin spalls were found. The low number of micro-burins can be explained by a decrease in importance of this specific technique, noticeable in general within late Early Mesolithic assemblages north of the main Alpine ridge. The low number of burin spalls can be simply explained by the scarcity of this type of tool in the assemblage in general, consisting of only three pieces. In this respect, it is interesting to note that the three burin spalls consist of the varieties RMG 1, 2 and 3, whereas the finished burins were only made of the variety RMG 1.

Among the artefacts where cortex residues were still present, the following observations were noted: objects of RMG 1 show mainly cortex residues characterized by natural fissure surfaces as well as scree surfaces or thin unrolled cortex surfaces. Fresh cortex remnants were only observed on four objects. As the proportions of scree cortex (n=136) and natural, unrolled or

		Schneiderküren		Egg-Schwarzwasser 1		Egg-Schwarzwasser 2		Egg-Schwarzwasser Stray finds	
Raw material varieties (diagnostic pieces >10 mm)		N	%	N	%	N	%	N	%
Local	T2_1	1825	68	637	46.4	208	24.2	120	41.2
	T2_5	380	14	497	36	382	44.4	90	30.9
	T1_1	80	3	185	13.4	250	29.1	72	24.7
Regional	Chert breccia	297	11.1	4	0.3	1	0.1	0	0
	Radioralrite Northern Alpine	16	0.6	15	1.1	11	1.3	6	2.1
	Flysch quarzite	0	0	14	1	1	0.1	1	0.3
	Spiculite	2	0	4	0.3	0	0	0	0
Exogenous	Baiersdorf	16	0.6	0	0	0	0	0	0
	Ortenburg	13	0.5	0	0	0	0	0	0
	Arnhofen	0	0	1	0.1	0	0	0	0
	Bavarian chert	0	0	3	0.1	5	0.6	1	0.3
	IT1/2	0	0	3	0.1	0	0	0	0
	IT1/4	0	0	2	0.1	0	0	0	0
Indet.		58	2.2	15	1.1	2	0.2	1	0.3
Total		**2687**	**100**	**1374**	**100**	**859**	**100**	**291**	**100**

Tab. 4 Raw materials Schneiderküren and Egg-Schwarzwasser (diagnostic assemblage)

slightly unrolled fissure surfaces (n=132) are roughly balanced, the use of stream gravels as well as the scree deposits directly below the primary raw material outcrops can be assumed. Among the varieties RMG 2 and 3, unrolled cortex and scree surfaces as well as natural unrolled fissure surfaces predominate as well. With regard to the regional raw material varieties RMG 4 and 5, scree surfaces and unrolled, scarred cortex predominate, which in turn suggests an exploitation of the residual deposits in rivers or moraine gravel.

Among the non-local raw material varieties RMG 6 (Baiersdorf), two cortical flakes and three cortical blades of phase 1 as well as ten blades and flakes of phase 2 are present. RMG 7 (Ortenburger Kontext) is represented with six cortical flakes and blades each, as well as eight blades and flakes assignable to phase 2. Additionally, chips of both varieties RMG 6 and 7 are present, as well as one micro-burin, which could be assigned to variety RMG 6. However, both preparations and cores are completely missing. A possible interpretation would be that only prefabricated blanks from different phases of the reduction sequence found their way into the Kleinwalsertal and were only later processed into tools here.

The data allow first insights into the raw material management at the Schneiderküren site. All phases and activities within the *chaîne opératoire* can be traced for objects from the local raw material varieties. The ensemble from the rock shelter follows the general Early Mesolithic trend towards a low core preparation, especially if the raw materials used are of somewhat inferior quality.[50] Among the few objects made from exogenous raw materials, the production sequence can only be reconstructed in parts. Cores are completely missing for these varieties. Cortical blanks and unmodified flakes and blades can also be found, suggesting either a targeted production of blanks at the camp or a transportation of blanks to the site for further processing.

Furthermore, it could be stated that phases 0 and 1 of the operation chain are clearly underrepresented among the local as well as the regional and exotic varieties at the rock shelter

50 Heinen 2012b.

		Schneiderküren								
		Local			Regional			Exogene		Indet.
		RMG 1	RMG 2	RMG 3	RMG 4	RMG 5	RMG 12	RMG 6	RMG 7	
Phase 0	Ro	0	0	0	0	0	0	0	0	0
Total Phase 0		0	0	0	0	0	0	0	0	0
Phase 1	Ka	102 (16)	35 (7)	6 (1)	32 (6)	0	0	2	2 (1)	0
	Kk	73 (8)	15 (1)	3	25 (2)	2 (1)	0	3	1	3
	Uk	0	0	0	0	0	0	0	0	1 (1)
	Pp	7 (1)	0	0	1	0	0	0	0	0
Total Phase 1		182 (25)	50 (8)	9 (1)	58 (8)	2 (1)	0	5	3 (1)	4 (1)
Phase 2	A	526 (101)	113 (20)	23 (4)	70 (10)	3 (1)	1	6	5 (2)	11
	Kl	401 (33)	72 (7)	17 (2)	48 (3)	6 (1)	1	2	4 (1)	4 (1)
	Ug	67 (67)	29 (28)	10 (10)	11 (11)	1 (1)	0	2 (2)	1 (1)	0
	Sp	10 (1)	2	0	0	0	0	0	0	0
	Ke	44	12	1	1	1	0	0	0	0
	Kt	25	7	1	0	0	0	0	0	0
	Siret	2 (1)	0	0	0	0	0	0	0	0
Total Phase 2		1075 (203)	235 (55)	52 (16)	130 (24)	11 (3)	2	11 (2)	10 (4)	15 (1)
Phase 3	Stab	1	1	1	0	0	0	0	0	0
	B	10	2	0	1	0	0	1	0	0
Total Phase 3		11	3	1	1	0	0	1	0	0
	Hat	62	1	0	0	0	0	0	0	1
	Tr	436	83	13	100	3	0	0	0	0
	Chip*	2846	873**		43	0	0	47	13	761
Total			**372**	**75**						
		4612	**1320**		**332**	**16**	**2**	**63**	**26**	**780**

Ro: nodule; Ka: cortical flake; Kk: cortical blade; Uk: cortical blank indet.; Pp: primary preparation; A: flake; Kl: blade; Ug: blank indet.; Sp: secondary preparation; Ke: core; Kt: core debris; Siret: "Siret" break; Stab: burin spall; B: burin; Ht: heat debris; Tr: debris; numbers in brackets = modified pieces

* Including undiagnostic pieces <10mm

** Since a clear distinction of RMG 2 and RMG 3 in the group chips was often not possible due to their small size and the similarity in colour and texture of the two RMGs, they were summarised in the generic group RMG 2/3.

Tab. 5 Reduction sequence Schneiderküren

Schneiderküren. This is not so surprising for the more distant varieties but is noticeable for the local ones due to the direct vicinity to radiolarite and chert deposits.

At the open-air site Egg-Schwarzwasser, a total of 3170 diagnostic artefacts was analysed, dividable into 1380 diagnostic pieces from Egg-Schwarzwasser 1, 863 pieces from Egg-Schwarzwasser 2 and 297 diagnostic stray finds (Tab. 3) Regarding the various raw materials, 12 RMGs were defined at the site (Fig. 13).[51] While various varieties appear in both lithic concentrations, others only appear isolated in one concentration (Tab. 4).

In the concentration Egg-Schwarzwasser 1, the largest RMG among the diagnostic pieces is RMG 1 (n=633), followed by RMG 2 (n=497) pieces and RMG 3 (n=185) objects. The regional varieties RMG 4, 5, 11 and 12, comprising chert from the Northern Alpine chert breccia, non-local radiolarian rock, Flysch quartzite and spiculite, are represented by 4, 15, 14 and 4 specimens in total. Furthermore, four exogenous RMGs were identified within this concentration: one burin made from chert – RMG 9 – originating from the area around Abensberg-Arnhofen (320km to the northeast); three objects made from Bavarian chert – RMG 10 – presumably from the context of the Franconian or Swabian Jura and/or their secondary deposits; and two RMG varieties from the region south of the main Alpine divide – RMG 13 and 14 – comprising five objects presumably originating from the Val di Non in Southern Tyrol at a distance of 190 km to the south of the Kleinwalsertal.

51 Posch – Brandl in press.

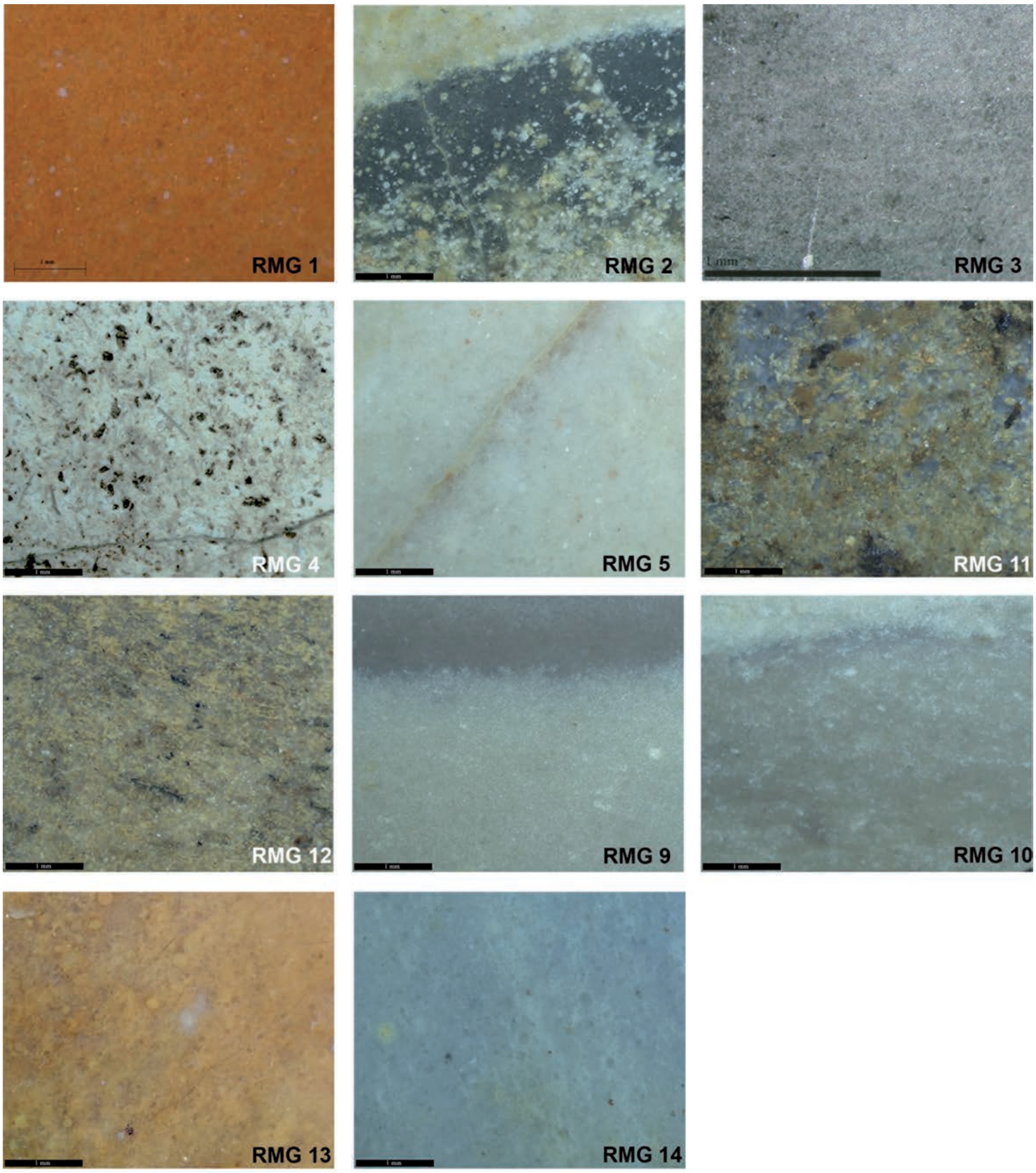

Fig. 13 Raw material varieties Egg-Schwarzwasser (photos: M. Brandl; RMG 1 after Brandl 2019, D142. Abb. 40)

In the ensemble of Egg-Schwarzwasser 2 the main RMG in the diagnostic assemblage is, interestingly, not the red RMG 1 (n=207), but the olive-green variety RMG 2 (n=382) and the blue cherts of RMG 3 (n=250). With this, the assemblage of Egg-Schwarzwasser 2 is the only assemblage in the whole region where RMG 1 is not the dominant raw material. The regional varieties RMG 4 and 5 are present with one and 11 specimens, whereas one object made from Flysch quartzite (RMG 11) is present. As an exogenous variety, five objects made from Bavarian chert (RMG 10) without clear affiliation to a geological deposit were found, again most likely from a Jurassic context farther to the north.

The lithic artefacts among the stray finds show the red RMG 1 as the dominant type (n=120), followed by 90 objects made from RMG 2 and 72 from RMG 3. Five objects originated from a broader regional context and are made either from radiolarite (RMG 6), which cannot be assigned to the local RMGs or from Flysch quartzite. Furthermore, one piece was assigned to the exogenous raw material chert variety RMG 10.

The examination of the reduction sequence of the whole assemblage of the concentration of Egg-Schwarzwasser (Tab. 6) showed that phase 0 is present only within the concentration Egg-Schwarzwasser 1 with a core from the RMG 2. The core seems to have been abandoned shortly after initiation of the production sequence, presumably since the raw material is very heterogeneous and lanced with fissures.

With regard to phase 1, in all concentrations, the three local raw material varieties (RMG 1–3) are present. However, primary preparations are very scarce and only appear within RMG 1 and 2 in Egg-Schwarzwasser 1 and amongst the stray finds. The regional varieties are considerably less frequent in phase 1. Only RMG 5 and 11 appear in Egg-Schwarzwasser 1, whereas other regional varieties are absent within phase 1. Exogenous raw materials are present in phase 1 with one piece in Egg-Schwarzwasser 1 and one piece in Egg-Schwarzwasser 2.

Also, phase 2 of the production sequence can be reconstructed for the three local raw material varieties RMG 1–3 in all artefact concentrations of Egg-Schwarzwasser, whereas the production sequences of the various and exogenous regional varieties are rather patchy. Preparations are again only present amongst the regional varieties and rather scarce.

Phase 3 is least represented within the concentrations of Egg-Schwarzwasser. Here, only a few micro-burins are present, which can be seen in a context with the production of microliths, whereas burin spalls are not present in any of the concentrations.

		***Chaîne opératoire* – Egg-Schwarzwasser 1**										
		Local			Regional				Exogenous			
		RMG 1	RMG 2	RMG 3	RMG 4	RMG 5	RMG 11	RMG 12	RMG 9	RMG 10	RMG 13	RMG 14
Phase 0	Ro	0	1	0	0	0	0	0	0	0	0	0
Total Phase 0		0	1	0	0	0	0	0	0	0	0	0
Phase 1	Ka	40 (2)	39 (2)	6 (1)	0	1	0	0	1 (1)	0	0	0
	Kk	42 (6)	17 (1)	4 (2)	0	2	1	0	0	0	0	0
	Uk	0	1 (1)	0	0	0	0	0	0	0	0	0
	Pp	2	2	0	0	0	0	0	0	0	0	0
Total Phase 1		84 (8)	59 (4)	10 (3)	0	3	1	0	1 (1)	0	0	0
Phase 2	A	174 (23)	149 (14)	44 (5)	1 (1)	3	7	3	0	1	3	2
	Kl	132 (36)	116 (21)	76 (11)	0	2 (1)	0	0	0	0	0	0
	Ug	1 (1)	4 (4)	0	0	0	0	0	0	0	0	0
	Sp	1	2	1	0	0	0	0	0	0	0	0
	Ke	10	15	3	0	3	1	0	0	0	0	0
	Kt	13	8	3	0	0	0	0	0	0	0	0
	Siret	7	1	0	0	0	0	0	0	0	0	0
Total Phase 2		341 (62)	295 (35)	123 (16)	1 (1)	8 (1)	8	3	0	1	3	2
Phase 3	Stab	0	0	0	0	0	0	0	0	0	0	0
	B	0	1	2	0	0	0	0	0	0	0	0
Total Phase 3		0	1	2	0	0	0	0	0	0	0	0
	Ht	2	0	0	0	0	0	0	0	2	0	0
	Chip*	209	189**		0	0	0	0	0	0	0	0
	Tr	209	136	49	3	4	5	1	0	0	0	0
Total			**492**	**184**								
		845	**865**		**4**	**15**	**14**	**4**	**1**	**3**	**3**	**2**

Ro: nodule; Ka: cortical flake; Kk: cortical blade; Uk: cortical blank indet.; Pp: primary preparation; A: flake; Kl: blade; Ug: blank indet.; Sp: secondary preparation; Ke: core; Kt: core debris; Siret: "Siret" break; Stab: burin spall; B: burin; Ht: heat debris; Tr: debris; numbers in brackets = modified pieces
* Including undiagnostic pieces <10mm
** Since a clear distinction of RMG 2 and RMG 3 in the group chips was often not possible due to their small size and the similarity in colour and texture of the two RMGs, they were summarised in the generic group RMG 2/3.

Tab. 6 Reduction sequence Egg-Schwarzwasser 1 and 2, and stray finds

		***Chaîne opératoire* – Egg-Schwarzwasser 2**						
		Local		Regional				Exogenous
		RMG 1	RMG 2	RMG 3	RMG 4	RMG 5	RMG 11	RMG 10
Phase 0	Ro	0	0	0	0	0	0	0
Total Phase 0		0	0	0	0	0	0	0
Phase 1	Ka	15 (1)	31 (2)	8 (1)	0	0	0	1 (1)
	Kk	7 (1)	14 (1)	17 (2)	0	0	0	0
Phase 1	Uk	0	0	0	0	0	0	0
	Pp	0	0	0	0	0	0	0
Total Phase 1		22 (2)	45 (3)	25 (3)	0	0	0	1 (1)
Phase 2	A	53 (8)	127 (20)	78 (8)	1	1 (1)	0	2
	Kl	52 (7)	81 (10)	74 (6)	0	1	1 (1)	1
	Ug	4 (4)	2 (2)	1 (1)	0	0	0	1 (1)
	Sp	1	6	2	0	0	0	0
	Ke	2	7	3	0	0	0	0
	Kt	7	2	1	0	0	0	0
	Siret	2	1	1	0	0	0	0
Total Phase 2		121 (19)	226 (32)	160 (15)	1	2 (1)	1 (1)	4 (1)
Phase 3	Stab	0	0	0	0	0	0	0
	B	4	1	2	0	0	0	0
Total Phase 3		4	1	2	0	0	0	0
	Ht	0	0	0	0	0	0	0
	Chip*	44	235		0	0	0	0
	Tr	59	107	61	0	9	0	1
Total			**382**	**250**				
		250	**867**		**1**	**11**	**1**	**6**

		***Chaîne opératoire* – Egg-Schwarzwasser stray finds**					
		Local		Regional			Exogenous
		RMG 1	RMG 2	RMG 3	RMG 5	RMG 11	RMG 10
Phase 0	Ro	0	0	0	0	0	0
Total Phase 0		0	0	0	0	0	0
Phase 1	Ka	11 (2)	10 (1)	4 (1)	1	0	0
	Kk	4 (1)	2 (1)	3	1	0	0
	Uk	0	0	0	0	0	0
	Pp	0	1	0	0	0	0
Total Phase 1		15 (3)	12 (2)	7 (1)	2	0	0
Phase 2	A	39 (2)	30 (4)	27 (3)	0	0	1 (1)
	Kl	21 (5)	19 (3)	15	0	1	0
	Ug	1 (1)	1 (1)	0	0	0	0
	Sp	1	1	5	1	0	0
	Ke	0	1	1	0	0	0
	Kt	1	1	3	0	0	0
	Siret	0	0	0	0	0	0
Total Phase 2		63 (8)	53 (8)	47 (3)	1	1	1
Phase 3	Stab	0	0	0	0	0	0
	B	0	1	1	0	0	0
Total Phase 3		0	1	1	0	0	0
	Ht	0	0	0	0	0	0
	Chip*	4	1	0	0	0	0
	Tr	38	23	16	3	0	0
Total		**120**	**90**	**71**	**6**	**1**	**1**

Tab. 6 continued

The objects from the local RMGs 1–3 Egg-Schwarzwasser varieties show mainly natural cleft surfaces, together with thin unrolled cortex surfaces and scree surfaces in second and third place. This again suggests an exploitation of either the local river gravels or of the sub-primary scree deposits directly below the primary outcrops. An important factor is the significantly less prevailing presence of the red RMG 1, which is usually the dominant raw material. In the case of the Egg-Schwarzwasser site, however, artefacts from the raw material variety RMG 2 occur in almost equal quantities as RMG 1, and at concentration Egg-Schwarzwasser 2, RMG 2 is even more abundantly represented than RMG 1, while RMG 3 is also much more strongly represented within this ensemble.

Discussion

Based on the available data – as shown above – various conclusions can be drawn regarding the proposed research questions at the beginning of this paper:

First, at both concentrations in Egg-Schwarzwasser (second half 9th/beginning of 8th millennium BCE) as well as at the rock shelter Schneiderküren (7th millennium BCE), the largest part of their raw material assemblages is composed of the local raw material varieties RMG 1, 2 and 3. However, there are differences in the quantities of the three varieties. At Egg-Schwarzwasser 1, RMG 1 dominates with 46.4% of the diagnostic assemblage, followed shortly after by RMG 2 with 36%. RMG 3 is represented by 13.4%. In Egg-Schwarzwasser 2, the picture changes, with RMG 2 as the dominant raw material variety with 44.4% and RMG 3 in second place with 29.1%. Here RMG 1 represents the third most used variety at 24.2%. At the younger site Schneiderküren, again a different composition occurs: RMG 1 now clearly emerges as the preferred type, with a share of 68 %, followed by the olive-green variety RMG 2 (14.14 %) and the blue RMG 3 (3 %).[52]

Therefore, we can conclude that at the earlier site Egg-Schwarzwasser the composition of the locally available raw material varieties used seems to be more heterogenous than at Schneiderküren, with RMG 1 and 2 appearing in once case in almost equal parts, and in the other, with a dominance of the green RMG 2 and an equally strong presence of the blue RMG 3. At the rock shelter Schneiderküren, the red RMG 1 clearly seems to be favoured. This preference in choice of raw material is surprising, insofar as all three local varieties appear within the same geological formation and feature the same physical knapping properties; therefore, this decision cannot be linked to functional aspects, and a deliberate preselection of nodules of the variety RMG 1 can be hypothesized for the Schneiderküren site.

Secondly, if we take a look at the respective reduction sequences, further interesting aspects become tangible. In both sites, the first two phases of the *chaîne opératoire* are significantly underrepresented. Phase 0 (raw nodules, tested pieces) is only found within the concentration Egg-Schwarzwasser 1 with a fresh nodule of the variety RMG 2. Unprocessed raw material nodules of all other local varieties are missing in Egg-Schwarzwasser, as well as at the Schneiderküren rock shelter. Furthermore, phase 1 (cortex blades and flakes, primary preparations) is represented in rather low quantities in both concentrations of Egg-Schwarzwasser and at the Schneiderküren rock shelter (see Tab. 5–6). Therefore, it seems possible that the decortification of the raw material blocks and nodules did not take place locally at the site.

Further conclusions can be drawn if we look at the available cortex surfaces of the artefacts made from local raw materials (Tab. 7): they feature mainly unrolled cleft and scree surfaces, indicating an origin of the raw materials from sub-primary scree deposits below the primary outcrops on the one hand, and from secondary deposits, such as river gravels, on the other. Regarding the exploitation of sub-primary resources, this presumably took place directly in the Gemsteltal

52 Posch – Brandl in press.

	Fresh cortex	Thin, unrolled cortex	Natural cleft surface, not unrolled	Natural cleft surfa-ce, unrolled	Scree surface	Indet.	0% cortex	Patinated surface
Schneiderküren								
T2_1	4	33	114	19	144	160	1344	15
T2_5	3	9	26	7	21	41	294	4
T1_1	0	1	5	0	4	9	60	1
Total	7	43	145	26	169	210	1698	79
%	0.3%	1.8%	6.1%	1.1%	7.1%	8.8%	71.4%	3.3%
Egg (Total)								
T2_1	9	54	147	21	82	12	551	38
T2_5	13	77	114	19	49	27	619	17
T1_1	0	10	65	8	23	13	322	4
Total	22	141	326	48	154	52	1492	15
%	1.0%	6.3%	14.5%	2.1%	6.8%	2.3%	66.3%	0.7%

Tab. 7 Cortex Egg-Schwarzwasser and Schneiderküren

valley itself. This assumption seems to be the most feasible due to the highest density and quality of radiolarite and chert varieties.

The process of raw material testing might have taken place directly at their original deposits, and only after the quality of the respective raw materials was deemed sufficient, were cores for further blank production chosen. Prior evaluation would make sense in the context of the locally available radiolarite and chert varieties due to their very heterogeneous character; it allows the quality of the nodule to be checked before it is taken away for further processing. Another interesting aspect in this case is that this process of preliminary testing can be documented at both sites. Therefore, first indications can be observed that the raw material procurement strategies stayed the same at least for the groups frequenting Egg-Schwarzwasser during the 9th and Schneiderküren during the 7th millennium BCE.

Such testing strategies have also been documented at other Early Mesolithic sites: for example, at the site Schleimsattel 3 (Preboreal to Early Boreal – c. 9600–8700 BCE), which lies directly on outcrops of the Ruhpolding Formation further to the east in the Karwendel region. In addition to a variety of cores, pre-cores and unworked nodules, the strategy of raw material testing can best be reconstructed through one specific piece, to which a single blow was administered. This blow resulted in the fracture of the whole raw material slap, which was afterwards abandoned due to its poor quality.[53] Also, at the southern German sites Siebenlinden 1, 2 and 3, testing of locally available Triassic chert raw materials of more challenging qualities has been documented. Nodules of these varieties were transported to the camps either tested or as pre-cores. Interestingly in this case, the non-local but higher-quality Jurassic chert reached the sites mainly as complete nodules, although its nearest outcrops lie at a distance of about 50 km from the campsites. It might be assumed that in this case, testing was not considered necessary due to the constantly good quality of the raw material slaps.[54]

Observations like this lead to further questions regarding the strategies employed for the procurement of lithic materials during the Mesolithic. In general, procurement strategies for raw materials needed for everyday activities during the Early and Late Mesolithic in southern Central Europe are understood as part of an ‘embedded procurement’.[55] Few examples are known where one might expect a direct targeted harvesting for more desirable and/or higher-quality

53 Schäfer 2006; Schäfer et al. 2016.
54 Kind 2006.
55 See e.g.: Kind 2006; Richter 2017.

lithic materials, such as the rock crystal procurement sites at the Riepenkar (2495 m asl)[56] and Fiescheralp[57] (2575 m asl.). However, examples for 'true' mining[58] activities during the Mesolithic are very scarce, and include, for instance, the Late Mesolithic rock crystal mining site Fuorcla da Strem Sut (2831 m asl., Stremlücke)[59], as well as the chocolate flint mine in Poręba Dzierżna, which was active from at least the onset of the Early Holocene onwards[60].

However, for the local radiolarite and chert deposits of the Kleinwalsertal, direct procurement strategies in the sense of mining activities – as have been assumed on various occasions in the past[61] – can as yet only be securely established for the Late Neolithic/Initial Bronze Age.[62] At the moment, a targeted collection of raw materials at the primary and/or sub-primary deposits of the region seems more plausible. Whether this was done in the context of an embedded procurement or during targeted excursions is difficult to say. Notwithstanding this, an interesting preselection by colour – at least during the late Early Mesolithic – is indicated by the clear dominance of red radiolarite varieties in the lithic assemblage at Schneiderküren.

In addition to the two excavated sites Egg-Schwarzwasser and Schneiderküren, the unexcavated surficial sites of the Kleinwalsertal also show high numbers of radiolarite and chert as their primary lithic resource. This is not surprising, since the sites are located in the direct vicinity of the respective primary outcrops.

Similar processes can be observed at sites in other regions with direct access to primary radiolarite outcrops, the upper Lechtal and Tannheimer Tal valleys, and the Karwendel and Rofan regions.[63]

Furthermore, in other sites in the context of the Northern Alps but farther away from these primary outcrops, radiolarite varieties appear as regular raw material resources, as can be seen, for example, at the Late Palaeolithic sites Altwasser-Höhle 1[64] and Unter den Seewänden[65], and in the Early and Late Mesolithic sequences of the rock shelter Oberriet – Abri Unterkobel[66], Rheinbalme, and Krinnenbalme[67].

Also in Mesolithic sites farther to the south, the use of Northern Alpine raw materials and especially radiolarite has been suggested: e.g. at the Preboreal site Kaiseralmschrofen, where 90% of the analysed lithic assemblage consists of lithic material from Northern Alpine contexts, also including large proportions of radiolarite and chert presumably from the Ruhpolding Formation.[68] Similarly, at the slightly younger Ullafels site, up to 37.6% of its lithic material can be classified as Northern Alpine radiolarite and chert, with a provenance from the outcrops of the Karwendel and Rofan mountains being the most likely.[69] At the Late Boreal site Alm 1 in the Kühtai Valley, radiolarite varieties from Northern Alpine contexts constitute the second largest part of the lithic inventory, next to the locally available quartz. Interestingly here too, the red variety T2_1, equivalent in colour to RMG 1 of the Kleinwalsertal sites, emerges as the preferred type at almost 61% of the flint inventory of the site.[70]

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56 Leitner et al. 2015.
57 Hess et al. 2021.
58 Mining = "the industry or activity of removing substances such as coal or metal from the ground by digging" (definition after Cambridge Dictionary, <https://dictionary.cambridge.org/de/worterbuch/englisch/mining> [last accessed 8 Feb. 2024]).
59 Reitmaier et al. 2016.
60 Sudoł-Procyk et al. 2021.
61 Binsteiner 2008; Leitner 2008.
62 Bachnetzer 2017.
63 Leitner et al. 2015.
64 Jagher et al. 2000.
65 Gehlen 1999; Gehlen 2001.
66 Wegmüller et al. 2013; Wegmüller 2022.
67 Laus 2006.
68 Schäfer et al. 2016.
69 Bertola 2011; Schäfer et al. 2016; Bertola et al. 2020.
70 Bachnetzer 2019; Brandl 2019.

The farthest southern indications of radiolarite as a raw material so far can be established for the Early Mesolithic site Weitenberg Alm[71], situated a few kilometres south of the Main Alpine Divide in Alto Adige.

To the north, radiolarite appears as a stable raw material variety in different quantities at sites throughout the Mesolithic sequence, like in the site cluster around the Forggensee,[72] as well as at the sites Jesenwang, Eismerszell und Pruk,[73] Essingen, Hattenhofen, Krautinsel and Leeder I.[74]

Further to the northwest in the Swabian Jura in the Mesolithic layers of the Helga Abri rock shelter (layers IIF1–6), a few objects of radiolarite were found, for which both an anthropogenic transport directly from the primary deposits and a collection of the raw material on the Iller-Lech-Platte region would be possible.[75] Furthermore, in the ensembles of the Early Mesolithic site of Henauhof-Nordwest[76] as well as the Late Mesolithic of Henauhof Nord II (Federsee region), red and green radiolarite varieties represent a standard component in the lithic inventory. Here it is interesting to note that among the pieces mainly extracted from the moraine gravels at the Federsee lake, three specimens of olive-green radiolarite were found. This variety is very similar to T2_5 (RMG 2) and does not occur naturally in the gravels of the region. Therefore, the authors assume an origin further east.[77] The Kleinwalsertal might be one of the available options.

Another site further to the west where Northern Alpine radiolarite was found was among the late Mesolithic finds of the lakeshore settlement Degersee I. Among these there were several objects of olive-green radiolarite. These included several objects which, according to the results of the provenance analyses carried out, could not only be assigned to the Northern Alpine radiolarite in general, but specifically to the deposits within the Große Walsertal and Kleinwalsertal.[78]

The most westerly documented pieces of Northern Alpine radiolarite as a raw material for tool production so far are the Early Mesolithic sites Berglibalm[79] and Flözerbändli[80] in the Swiss Bisisthal. However, radiolarite is here only represented as single pieces within the lithic inventories.

Conclusions

Radiolarite and chert of Northern Alpine origin can be seen as one of the staple raw materials in Mesolithic sites of western Austria and in parts also to its adjacent northern region. In the case of western Austria, at least for those sites situated directly in the Northern Limestone Alps, the vicinity to these raw material resources can be seen as the main driving factor. This also holds true for the Kleinwalsertal and the two studied sites, Egg-Schwarzwasser and Schneiderküren. Here, we observe a clear preference for the locally available raw material varieties. However, there seems to be a shift in the colour preference from the first half of the Early Mesolithic to the later phases, as the lithic inventory of the rock shelter Schneiderküren shows a clear dominance of the red variety T2_1 = RMG 1. A selection of this chert variety based on better knapping properties

71 Schäfer et al. 2016.
72 Gehlen 2010.
73 Graf 2015.
74 Richter 2017.
75 Hahn – Scheer 1983; Hess 2019.
76 Jochim 1993.
77 Kind 1997.
78 Kaiser 2015.
79 Leuzinger et al. 2020.
80 Leuzinger et al. 2022.

can be negated, as they are similar or the same for all three local varieties. Therefore, one of the reasons for this choice could possibly have been its striking red colour.

Furthermore, the available data suggest an exploitation of the residual deposits within the riverbeds of the southern half of the region as well as the sub-primary scree or block rubble deposits within the Gemsteltal valley.

The evidence of the exploitation of radiolarian rock and chert varieties directly in the Gemsteltal valley raises the question of the extent to which Mesolithic mining can be assumed, as it has been in previous publications. As for the Kleinwalsertal, for now, the only reliable evidence of targeted radiolarite mining can be dated to the 3rd to the 2nd millennium BC at the quarry site Am Feuerstein. For the preceding phases, a more or less targeted gathering activity of the block rubble on the scree deposits directly below or at the primary radiolarian rock outcrops seems more likely.

This exploitation of lithic raw materials directly at their sub-primary source has a number of advantages for the Mesolithic HGF of the region, e.g. a much wider range of radiolarian rock and chert.

An exploitation of these sub-primary resources is further substantiated by low values of cortex blanks and primary preparations of phase 1, suggesting that the local varieties were subjected to initial testing before they were taken to the campsites. This makes sense, since the radiolarian rock varieties of the Gemsteltal valley show a very heterogeneous internal structure, and good knapping properties cannot be assumed per se.

However, the actual strategies for the exploitation of these raw materials do not seem to have changed through time and are the same for Egg-Schwarzwasser and Schneiderküren.

But also in other areas (see Discussion), lying at a greater distance from primary outcrops of the Ruhpolding Formation, radiolarite and Northern Alpine chert remain an important raw material variety in the available lithic assemblages. Furthermore, this is not linked to a specific period but stretches through the end of the Pleistocene and into the first millennia of the subsequent Holocene.

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