Silex raw materials from the Kelheim district (Bavaria, Germany) in the lithic assemblage of the Lower Mesolithic site Ullafelsen (Tyrolean Alps, Austria)

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1. Introduction

The Lower Mesolithic site Ullafelsen is situated in the Fotscher Valley (Fotschertal) in Tyrol at an altitude of 1869 meter above mean sea level. The site was excavated from 1995 to 2004 by a team of archaeologists from the University of Innsbruck under the direction of one of the authors (DS). The Fotscher Valley is part of the northern Stubai Alps. Its geological setting is characterized by the presence of metamorphic rocks, mainly mica schist and gneiss but without any natural deposits of siliceous raw materials (“silex”, e. g. chert, hornstone, radiolarite, etc.). The mesolithic occupants of Ullafelsen had to acquire these rocks (important for the production of stone tools) from various, more or less distant regions. Therefore, a raw material analysis of the Ullafelsen assemblage offered an excellent opportunity to establish concepts of subsistence strategies and transportation networks during the early Holocene.

The Ullafelsen lithic assemblage contains artefacts made of silex from the Northern Limestone Alps (Nördliche Kalkalpen) as well as from Northern Italy (Trentino Province), and other localities. Of special interest, however, are cherts deriving from the region of the southern Franconian Alb. They mark not only the farthest range of silex acquisition with a straight distance from Ullafelsen of more than 200 km but also allow significant intercultural contacts between the two areas to be taken into consideration. The Lower Mesolithic of the Altmühl and Danube river valleys belongs to the South German *Beuronian* lithic tradition, while Ullafelsen and the Fotscher valley are close to the South

Alpine region and its different *Sauveterian* tradition of the Lower Mesolithic in Italy. The presence of south alpine silex from northern Italian sources, together with Bavarian raw material in the Ullafelsen assemblage, provides such cultural relationships with a strong supporting argument. In this paper, we will present chert artefacts from Ullafelsen with geological origins in the Altmühl/Danube region and discuss their importance for the Ullafelsen assemblage.

2. Palaeogeography of Southern Germany during the Upper Jurassic and the distribution of chert bearing limestones of the Frankonian Alb. An overview

In the Upper Jurassic period, Southern Germany was situated on the margins of the European continental block, which was then separated from the African block by the Tethys Sea. The paleogeographical pattern was characterised by a system of algal-sponges and coral reefs adjacent to basins which were not very large or deep in the southern Franconian area, while in Swabian-North Franconia mainly marly basins appeared (Fig. 1) (Meyer & Schmidt-Kaler, 1984, 1989). The more ancient occurrence of cherts in the Bavarian realm is dated to the middle Kimmeridgian (Malm Delta). These cherts are embedded into thick bedded limestones of the Treuchtlingen formation andare found only in the easternmost part (Dietfurt, Parsberger Riffzug, Ebenwies) of a vast platform. The platform was constituted by a succession of biostromes formed by siliceous sponges intercalated with micritic mud (Meyer & Schmidt-Kaler, 1984, 24–25, 156–159; 1996, 107, Beilage 3). Here chert nodules as well as chert layers are present, often dolomitised and mostly

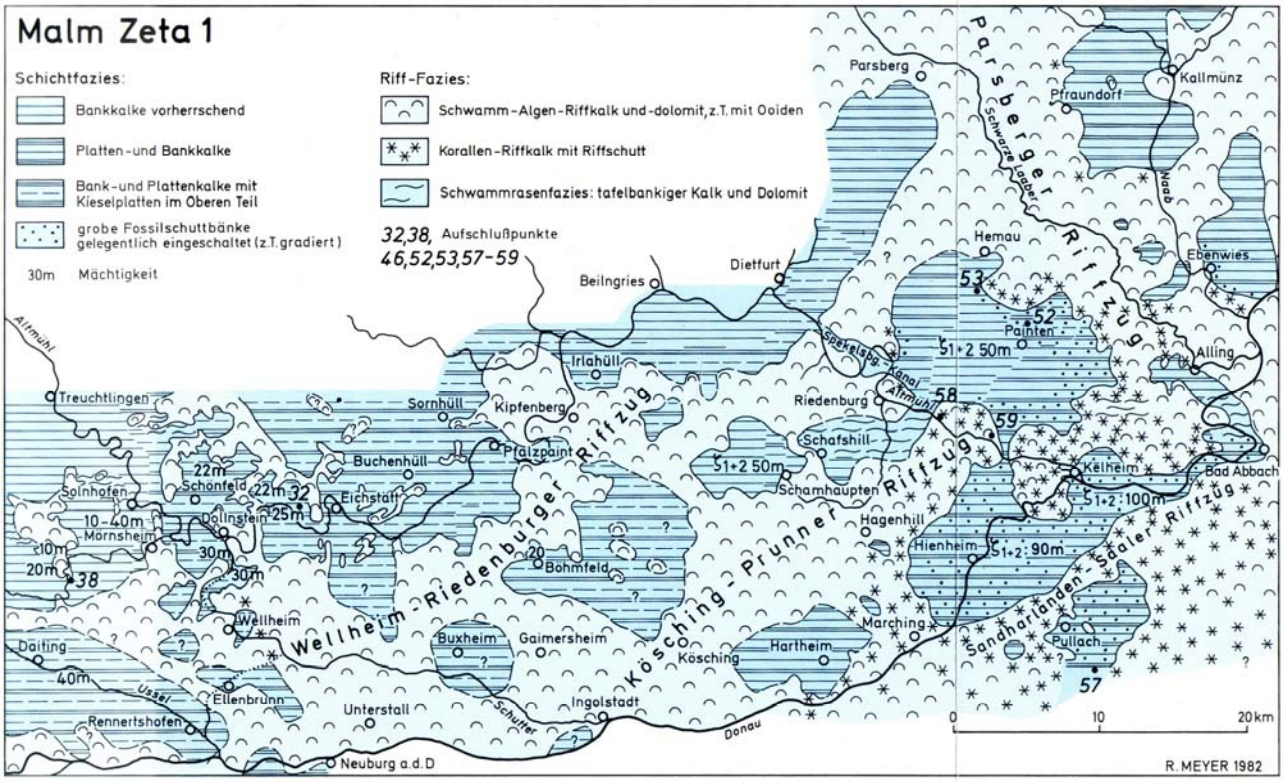

Figure 1: Paleo-geographical map of southern Franconian Alb during Malm Zeta 1 (from Meyer & Schmidt-Kaler, 1984, Beilage 1). The relative position of the reefs and of the basins are quite stable in the considered interval (Malm Deltato Zeta; middle Kimmeridgian to lower Tithonian).

not suitable for knapping (Binsteiner, 1990). Throughout the entire Malm Epsilon sequence, bedded limestones containing high amounts of chert nodules are described in some small basins of the Nothern Franconian Alb (Pobbberg, Hollfeld und Wattendorf) that developed between the now dolomitised reefs (Meyer & Schmidt-Kaler, 1989, 24). During the upper Kimmeridgian until the lower Tithonian interval (Malm Epsilon + Zeta) limestone that locally contains chert nodules and slabs was deposited as thick-layered strata (Plattenkalke) in the basins of the southern Franconian Alb region (Altmühl-Alb). In Malm Epsilon deposits (Epsilon 2 = Setatum zone), chert layers and nodules frequently appear in the basins of the south eastern part of the Franconian Alb (Painten, Hienheim-Kelheim) but are lacking in its western part (Solnhofen-Eichstatt region) (Schmidt-Kaler, 1979, 12; Meyer & Schmidt-Kaler, 1984, 42). During Malm Zeta 1 and 2 chert layers and nodules were mainly formed in the central southern part of Franconian Alb. This silex is usually distributed near the margins of the spongeous reefs but can also be found in the centres of the basins (Meyer & Schmidt-Kaler, 1984, 183; 1989, 27). The Malm Zeta 3 sequence is characterised by alternating thin layers of chert and thicker bedded limestones in the basins of the southwestern Franconian Alb (Mornsheim, Solnhofen, Eichstatt, Ingolstadt). The silica was mainly supplied by the sponges which proliferated around the reefs. In depressed zones or areas with restricted circulation anoxic conditions existed that led to the accumulation of bituminous sediments at the bottom (Keupp, 1977; Viohl, 1998). Such basins were predominant in the southern Franconian Alb region. The basins were located in the innermost as well as the outmost areas of the continental margin and were more or less interconnected. Although they were formed at the same time, they maintain a few distinctive features, for example, their chert-bearing horizons show different frequencies and varieties.

Two of these basins have been mentioned in the literature because of their characteristic cherts. The "Paintner Wanne",which contains thin brownish plates with a hard cortex, is known as 'Baiersdorf type' (Binsteiner, 1989). The other is the smaller "Abensberger – Pullacher Wanne" where a typically tabular and banded form of chert is strtified over time (Moser, 1978; Binsteiner & Engelhardt, 1987; Engelhardt & Binsteiner, 1988; Binsteiner, 1990). All other types of chert from the Franconian Alb do not show characteristic and distinguishable features that would allow a determination of the basins or areas of origin (Grooth, 1994, 362-366).

In the first part of this paper we will describe chert samples from the famous Neolithic Abensberg–Arnhofen quarry (kindly supplied by Dr. M. M. Rind, Kelheim). Then, we will compare them with a group of artefacts from the Mesolithic site of Ullafelsen which we consider to belong to this type of chert.

3. Characterisation of the geological chert samples from Abensberg-Arnhofen

The samples were obtained from two Neolithic chert mining pits. They represent the typical and characteristic varieties but are not representative of the entire variability of the chert from this area. The cherts were located in a secondary position, within a specific soil horizon, buried under more recent fluviatile gravels (Meyer et al., 1994). Originally, they were embedded in Malm Zeta 1 and 2 limestones (Rind, 2000, 2006; Binsteiner, 1990). The samples can be classified into two groups, here named as Geological Type 1 and Geological Type 2.

3.1 Geological Type 1 (Fig. 5a-b;e-f))

This kind of chert is described as the most typical variety of the Abensberg-Arnhofen group (Grooth, 1994; www.flintsource.net). The cortex is yellowish (2.5Y 7/4) (Munsell, 1990) and thin (2-3 mm), the wall rock is a thin calcarenite and slightly marly. The morphology is mainly tabular, its layers are between 1-2 cm up to 5 cm thick. The chert is opaque in texture. A typical feature is formed by the alternation of homogeneous and fine crystalline vitreous horizontal stripes/bands of a dark grey (2.5Y 3/0, 4/0) or greenish grey (2.5Y 3/2, 4/2) colour with less silified laminated or micro-laminated bands ranging from light grey to milk white colours (2.5Y 5/0, 6/0, 7/0, 8/0). Some samples also present a green- or purplish-brown banding. Stripes/bands only few millimetres to centimetres in thickness alternate. They become more evident if the chert surfaces are patinated due to weathering. Here also a changing in colour from the original grey to greenish and, sometimes, even blackish can be observed.

The chert appears not as very uniform, due to different grades of silification of the various alternating bands. At times, there can be elongated cavities (centimetric scale) filled with geopetal quartz; its crystals are already visible with the bare eye. Few intraclasts of maximum centimetric sizes were observed.

The alternation of microlaminated bands with homogeneous and vitreous ones is a feature inherited from the original sediment and attributable to calm pelagic sedimentation interrupted by turbidity or whitening episodes. The microlaminated horizons correspond to the normal sedimentation of the basin. The lamination is principally due to microbiological algae, whereas the lack of bioturbation is caused by the presence of anoxic bottom waters (Fursich et al. 2007, 112-113; Munnecke et al., 2008, 1933-1934). These horizons are densely layered, in the range of a tenth millimetre, or even less; no microfossils are detectable. They alternate with homogeneous non laminated bands full of microfossils, sometimes graded. One can easily identify crinoid fragments, numerous sponge spicules (mostly monoaxone, some triaxone), calcispheres and poorly preserved radiolarians. Some mainly spherical ooids of few millimeters in size, with whitish and opaque textures, are also present. Benthic foraminifera and pelagic bivalvia are less common.

In the Franconian Alb there are many other Jurassic chert outcrops of a similar age. However they are not characterised by the same banded feature typically associated with thin tabular morphology (www.flintsource.net; Grooth, 1994).

3.2 Geological type 2 (Fig. 5c-d)

This type of chert is different from the first one because of its uniformity. The cortex is made of white or slightly yellow micrite/thin calcarenite, a bit uneven and not very marly. The typical grey and white horizontal banding is limited and mainly restricted to the peripheral areas near the cortex. There are both tabular layers and sub-rounded nodules, in colour ranging from light to dark grey. The prevailing colour is 2.5Y 3/0 and 4/0 which alternates with colour stripes or bands of 2.5Y 5/0, 6/0, 7/0, often only some of these are present. The most frequent association is 2.5Y 3/0 + 2.5Y 7/0 (subdued on the margins). The nodules can be up to 15-20 cm long and 5-6 cm thick. The chert is

Figure 5*: Overview of geological chert samples type 1 (a,b) and type 2 (c,d) from Abensberg-Arnhofen; details of geological chert type 1 (e,f).*
5e (x8) (geological type 1 chert sample). Alternation of withish microlaminated and graysh graded bands (cfr. Fig. 4 – 3b). Most of graded grains are bioclasts. 5f (x15) (same geological sample). The surface of one graded band showing a fossil association made mainly by sponge spiculas, radiolarians and calcispheres.

very dense and of fine crystalline structure. The characteristics are the same as for the most silified and darkest areas of geological type 1, whereas the less silified bands are rare or absent. No microlaminated horizons can be observed. Some of the chert specimens appear translucent. The degree of silification is high or very high, and the aspect is very homogeneous. No structures are visible in the matrix which also shows a poor preservation of microfossils. Only sometimes was it possible to detect sponge spicules, bryozoa fragments, calcispheres, whitish radiolarians and ooids, and fragments of pelagic crinoids (*Saccocoma*). A few microfossil cavities present brownish replenishments. In the lesser silified areas, the colour appears more whitish with different tones. These are peripheral areas (toward the cortex) or big tabular limestone remains, almost completely silified, which can be distinguished from the matrix by a light grey or whitish chromatic variation. Such areas appear slightly rougher and are often surrounded by a brown halo (2.5Y 4/2). The presence and preservation of microfossils is progressively increasing from the more to the lesser silified areas. Compared to geological type 1, the micropalaeontological association doesn't change: on the contrary, the quantitative rapports vary. There is a minor presence of spongeous spicules but also of other forms that are not of planktic origin, which probably indicates a more calm sedimentation. The microfossils of the darker specimens present blackish replenishments with a metallic appearance (probably sulphides). The dark grey, almost black colour is a sign of anoxic environment and also suggests the probable presence of dispersed organic substance. Other specimens have lesser dark and marked shades. However, the most frequent colour is dark grey.

4. The Ullafelsen artefacts

The Ullafelsen lithic assemblage is composed of several types of chert and radiolarites. This includes a group of artefacts compatible with the Upper Jurassic chert types from Franconian Alb. We analyzed only a sample, constituted by the bigger artefacts. There are more (smaller) artefacts which were not included in this analysis. Analysing the artefacts in detail, only few artefacts show a close similarity with the previously described geological chert samples from Abensberg-Arnhofen. In the following descriptions these artefacts have been subdivided into Archeological Type 2.1 and 2.2.

4.1 Archaeological Type 2 - Group of artefacts corresponding to the Abensberg-Arnhofen geological types (Fig. 3)

This group is smaller (in total 107 artefacts) than Archeological Type 1 (350 artefacts, see below). It includes lithotypes that can be compared with the geological specimen from Abensberg–Arnhofen. Some of them represent the characteristic greyish and whitish horizontally striped texture, others are more homogeneous. They are generally more silified than Archeological Type 1. We divided them in two subtypes (Archaeological subtypes 2.1 and 2.2) due to some minor differences.

Figure 3: Ullafelsen inventory. Overview of artefacts belonging to archaelogical type 2. Note the striped feature of most of them; the stripes are in the most of cases parallel to the planar cortex.

4.1.1 Archaeological subtype 2.1 (Fig. 3a,c,d,f; Fig. 4.3a,b)

It is characterised by light grey fine crystalline chert with typical whitish horizontal bands of a paler shade. They are usually rectilineal, but sometimes show a sinuous pattern. These bands are never numerous and always subordinate. The cortex is thin and whitish with a planar disposition. The geological referring blocks are assumed to be chert beds. The withish stripes show, more or less clearly, a micro-laminated aspect; the lamina are often discontinuous and caused by microbial mats. Sometimes this microfacies is close to graded bioclastic horizonts. This subtype falls into the Geological Type 1 of the Abensberg–Arnhofen samples.

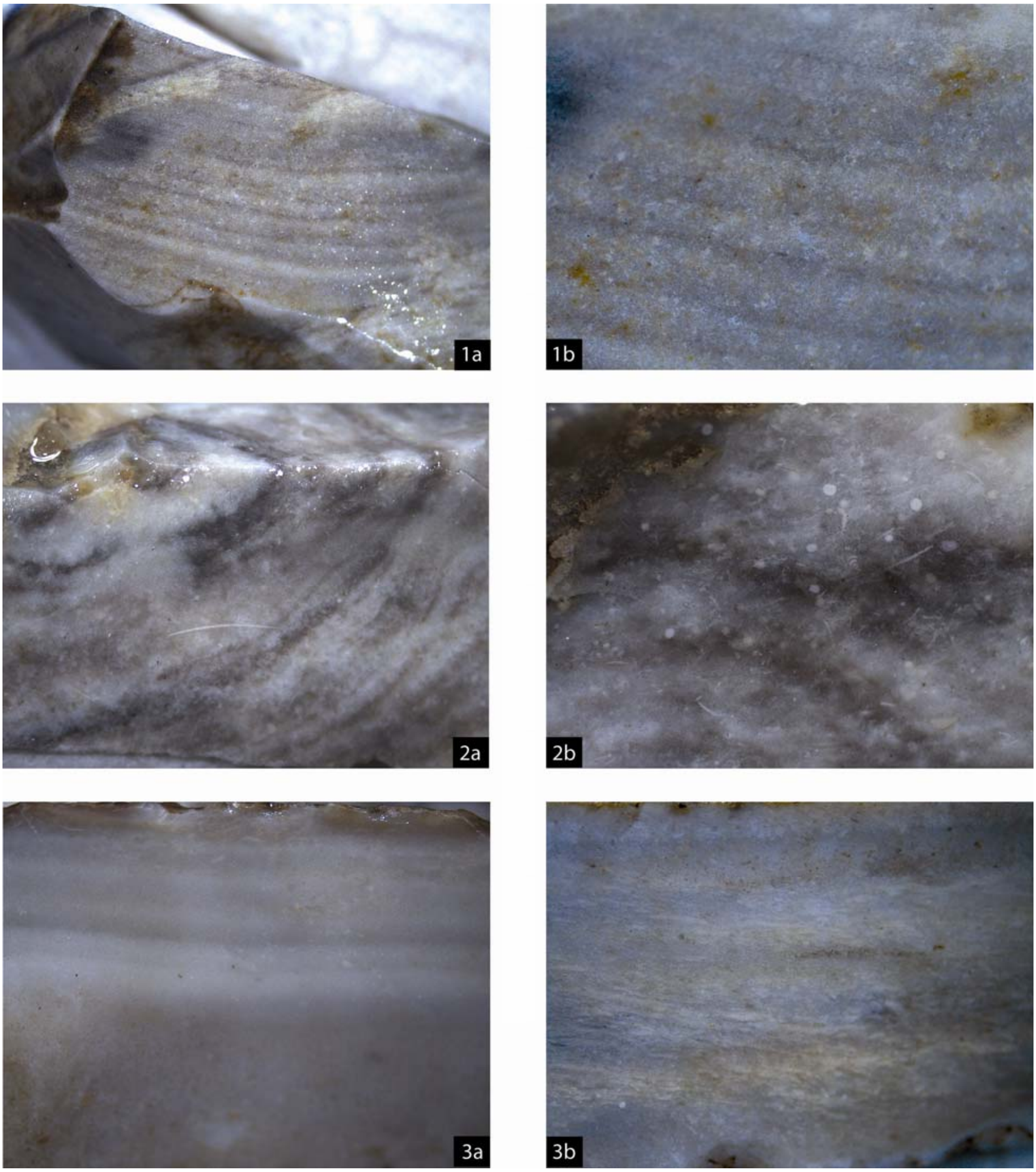

Figure 4*: Ullafelsen inventory. 1 and 2: details of some artefacts belonging to archaelogical type 1 chert; 3: details of some artefacts belonging to archaelogical type 2.1 chert.*

1a (x8) and 1b (x20) (artefact C5 – 541). In evidence the fine lamination and the poorly preserved fossil association (mainly sponge spiculas, radiolarians and calcispheres).

2a (x8) and 2b (x16) (artefact C6 – 124). In some areas, expecially near the cortex, the fossils are better visible: a thin bivalvia shell (2a), benthic foraminifera, radiolarians, calcispheres and sponge spiculas (2b).

3a (x8) (artefact C5 – 122). Fine crystalline chert with the characteristic planar white stripes alternating to gray ones. 3b (x8) (artefact B6 – 163). Alternation of withish microlaminated and graysh graded stripes.

4.1.2 Archaeological subtype 2.2 (Fig. 3b,e)

This type shows some chromatic variations of the most silicified areas, which are slightly darker than subtype 2.1. The chert is always of a fine crystalline structure, the cortical areas are thicker, the lesser silified bands are rare and visible only on larger artefacts. The chert is similar to the Archaeological subtype 2.1, but is more amorphous and lacks evident structures. The referring geological blocks are assumed to be nodules. This subtype is associated with the Geological Type 2 of the samples from Abensberg–Arnhofen.

4.2 Archaeological Type 1–Group of artefacts generally attributed to the Upper Jurassic cherts of the Franconian Alb (Fig. 2; Fig. 4.1a, 1b, 4.2a, 2b)

This group is less crystalline and homogeneous than the Archaeological Type 2. The cortex is whitish; locally it is covered by calcite concretions impregnated with oxides of an orange-brown colour. The colour and texture of the chert are inhomogeneous. The siliceous matrix is brown or grey, with frequent and dense dark grey laminations and elongated bands or stripes, sometimes also discontinuous and of an ivory-white colour, predominantly in the outer zones. Because of an alteration process, sometimes the grey colour turns into brown or green. The degree of silification is variable. Most of the artefacts are made from slightly silified nodules. In the largest specimens, the outer areas are more silified, while the chert appears impure and uneven towards the centre of the blocks. The texture shows laminations and bands, also discontinuous, providing the chert with a marbled texture. Dark grey colours alternate with whitish and beige. Generally the laminae are thick and possess a rectilinear or curvy pattern. Ivory-white colours appear mainly in the outer parts. The matrix is impenetrable by light, opaque. The fossils are generally poorly preserved and hardly visible. Small radiolarians, calcispheres, sponge spicules, crinoid articles and small algal nodules are visible mainly around the cortex and in the more silified specimens. Locally, in a centimetric scale, there is a prevalence of stripes or patches upon very thick laminae; several refitted artefacts show a compatibility of these variants. In other cases artefacts with a different degree of silification and different colours could be fitted together, thus showing a certain variability of the chert. Some artefacts, mainly cortical flakes, are predominantly whitish or ivory in colour, in line with the previous descriptions. On the latter samples, the laminae and the patchings appear almost reddish. The morphological characteristics visible on the cortex of the artefacts allow the conclusion that the chert was available in the form of nodules as well as beds.

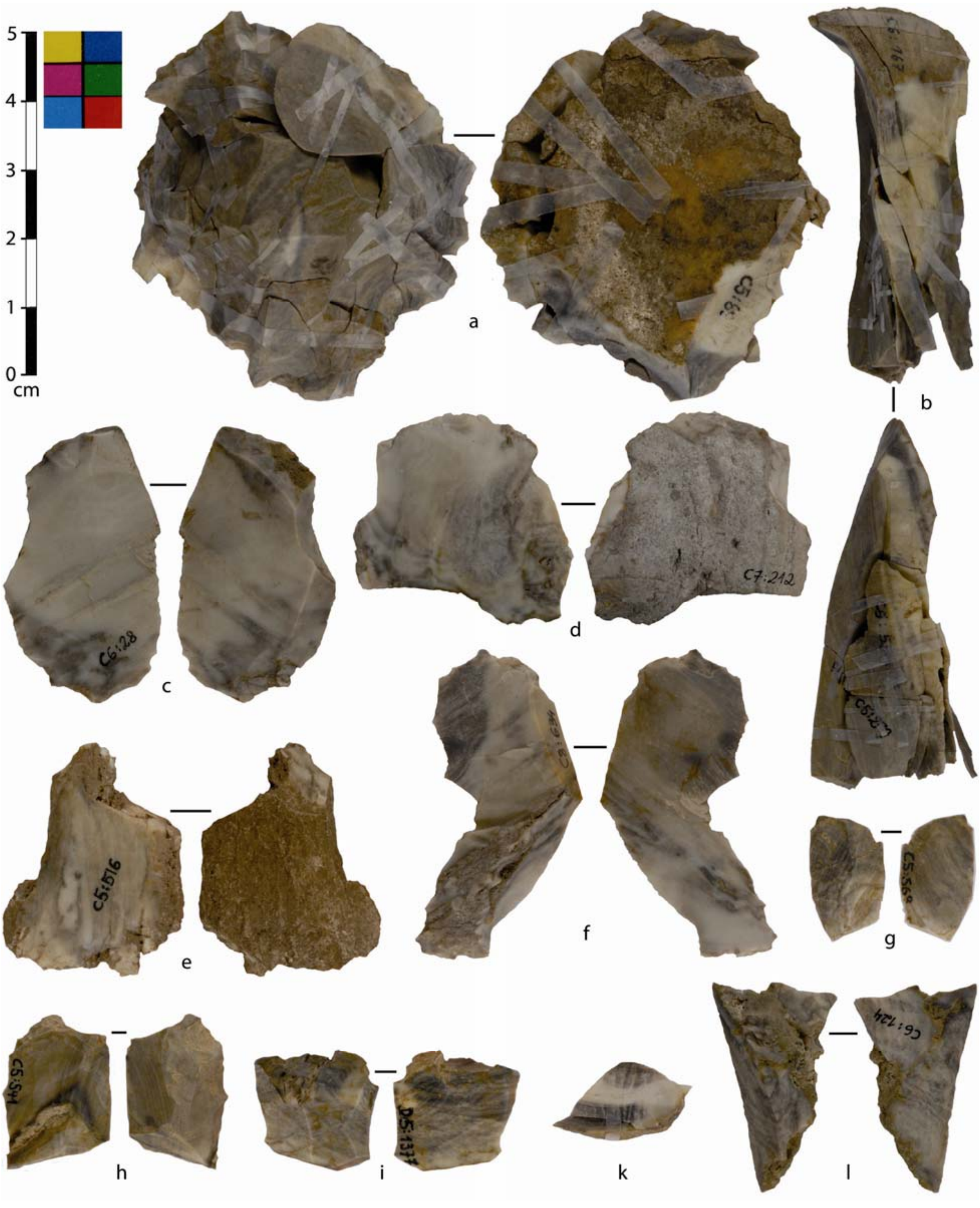

***Figure 2**: Ullafelsen inventory. Overview of several artefacts belonging to archaelogical type 1. Many of them (a, b) fit together (refits by J. Ullmann) demonstrating that the raw material was chipped in the site.*

5. Discussion

The groups of artefacts described can be attributed with high certainty to the upper Jurassic cherts from the "Plattenkalke" of southern Franconian Alb. A number of indications support this hypothesis: firstly, the macroscopic features of the samples (colour, structure, cortex) and secondly, the microscopic study that revealed the fine lamination and the nature of the fossil content with spongeous spiculas, calcispheres, crinoid fragments, ooids and algae.

The Upper Jurassic "Plattenkalk" of southern Germany is characterised by an alternating sequence of very fine grained and pure limestone (Flinze beds, 95-98 $CaCO_3$) and interbedded marly micritic limestones (Fäule beds, 85-90 $CaCO_3$). The presence of microlaminated horizons attributable to cyanobacterial microbialites is another characteristic feature. The authors regard this microlamination as caused by the action of microbial mats that stabilized the surface of the sediments at the bottom of the basins (Viohl, 1994, 1998). The nature of the original limestone apparently influenced the subsequent silification. This process might explain the banded aspect of several chert lithotypes. We observed that the microlaminated horizons were often resistent to the silification process.

Within the lagoonal systems of the Franconian Alb several laminated limestones (Plattenkalke) were recognized during the Kimmeridgian–Titonian. The basins differ for their dimension and their position, more or less far from the margins of the lagoons towards the open sea. The classic Solnhofen–Eichstätt region must have been in an interior position, since the laminated limestone shows no indication of intermediate coarser-grained and graded horizons (submarine flows, turbidites). In more marginal positions were Schamhaupten, Painten and Kelheim, evidenced by the common presence of turbidite intercalations, and Hienheim and Brunn, due to their rich bentic fauna (Fursich et al. 2007, 115). The northern Tethys shelf shows a tendency towards shallow waters. It is demonstrated by an increasing presence of Hermatypic corals in late Kimmeridgian, until they became abundant in the late Tithonian. Also, numerous reef detritus and ooids appear in the sediments. This tendency is sometimes difficult to distinguish in the different basins only on the basis of the palaeontological association in the cherts: the chronology and correlation of these formations depends mostly on Ammonite zonation. However, these fossils are very rarely preserved in chert layers and beds.

The artefacts belonging to the Archaeological subtype 2.1 show clear evidence of microlaminated horizons alternated to graded horizons as described for certain intervals of the 'Plattenkalke'. The graded horizons have been referred to turbidity currents or suspension clouds (Fursich et al. 2007, 97-100). This subtype is very similar to the typical variety of the "Abensberger-Pullacher Wanne" as described in the literature.

The artefacts that belong to the Archaeological subtype 2.2 are very similar to the Geological Type 2 as mentioned above, also originating from the Abensberg area and belonging to the variations of the "Abensberger-Pullacher Wanne" chert, but in some way different (nodules instead of thin slabs, uniform aspect) from the very typical chert from Abensberg as described in the literature.

The artefacts belonging to the Archaeological Type 1 have some characteristics different from both Archaeological Type 2.1 and 2.2. This type never showed the typical continuous banded pattern in a centimetric scale. On the contrary, it has thick millimetric laminations. They can be continuous and discontinuous with rectilineal but also curvilinear shapes. Also it contains very small algal nodules. We did not recognize graded horizons, the evidences suggest that it formed in an environment wich was not influenced by turbidites. This type does not fall into the range of all the geological samples from the Abensberg–Arnhofen area used in the descriptions above. Obviously, the available samples do not represent the entire variability of the cherts from the "Abensberger–Pullacher Wanne"; however, given that the Archaeological Type 1 is compatible with the Jurassic cherts from other areas of the Franconian Alb and appears similar to some chert samples from the surroundings of Kelheim (Kelheimwinzer) and also to other samples from the Eichstätt region (Moritzbrunn, Adelschlag) (published online at http://www.flintsource.net). The sourcing and mapping of this kind of chert has yet to be ascertained.

6. Archaeological consequences

In spite of some uncertainties in the knowledge of lithic raw material varieties of the Franconian Alb, it can be stated that at least a good share of the Ullafelsen artefacts has its geological origin in the „Abensberg-Pullacher Wanne“, about 200km north of Ullafelsen in straight line. However, the actual route taken by the Mesolithic people was undoubtedly considerably longer.

Furthermore, several artefacts from Ullafelsen are made of raw materials from the region of Val di Non in Upper Italy, thus proving the existence of a southward route (Bertola 2005; Bertola, in prep.). Hence, contacts between the Sauveterian culture of the Southern Alps and the Southern German Beuronian can be considered as highly probable. The hypothesis of such a relationship receives further support from the artefact record: a number of backed bladelets was found at the Ullafelsen site. They are characteristic of the Sauveterian, a lithic tradition that continued from the Würmian “Epigravettiano recente“ into the Holocene. As far as present knowledge goes, however, this tradition is more or less absent in Beuronian contexts. Since all recovered backed bladelets from Ullafelsen were made of Southern Alpine Silex, it can be considered that their manufacturers were most likely associated with the Southern Alpine tradition as well. Also several needle-shaped points from Ullafelsen appear to be connected to the Southern Alpine Early Mesolithic. Except one made of rock crystal, they were all made of Southern Alpine silex. On the other hand, the Ullafelsen assemblage includes an elongated and narrow microlith trapeze made of Franconian chert. This artefact type has no equivalent in Southern Alpine contexts but is known from Beuronian assemblages.

By tracking back the origins of lithic raw materials, a tangible conception of the dimensions of such seasonally used routes during the Early Mesolithic can be obtained. Raw material studies are, therefore, of immense value for the understanding of subsistence patterns and seasonal movements as well as supra-regional traditions in the development of the Eastern Alpine Mesolithic.

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