ANTHROPOLOGIE
INTERNATIONAL JOURNAL OF HUMAN DIVERSITY AND EVOLUTION

Special Issue:
Focus on the lithics: raw materials and their utilisation during the Stone Age in Central Europe

Guest Editors:
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ANTHROPOLOGIE • LV/1–2 • pp. 181–191 • 2017

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ANALYSIS OF A BAIERSDORF SICKLE BLADE FROM EASTERN AUSTRIA

ZUSAMMENFASSUNG: Die Sichelklinge vom Altheimer Typ (etwa 1. Hälfte 4. Jahrtausend v. Chr.) von Annastift-Krummnußbaum in Niederösterreich stellt das bislang schönste und auch komplett erhaltene neolithische Erntegerät dieser Art in Ostösterreich dar. Die Lagerstätte des aus jurassischem Plattenhornstein gefertigten Stückes befindet sich in Baiersdorf am oberen Donauverlauf im Raum westlich von Regensburg im nördlichsten Niederbayern (Deutschland) und ist als Fertigprodukt das Donautal stromabwärts verbracht worden. Kulturell gehört die Sichelklinge dem Pfyn-Altheim-Mondsee Kulturkomplex an, der östlich davon im Mitteldonauraum dem Horizont der Furchenstichkeramik bzw. Baalberge sowie einem frühen Baden (Boleráz) entspricht.
Die Herkunftsbestimmung wurde durch den mittlerweile international etablierten Multi Layered Chert Sourcing Approach (MLA) durchgeführt. Diese Methode beruht auf einer Kombination aus makroskopischer (visuell-vergleichender), stereomikroskopischer und geochemischer Analytik. Für geochemische Untersuchungen wurde Laser Ablation Inductively Coupled Mass Spectrometry (LA-ICP-MS) eingesetzt, eine Methode, die den Nachweis von Haupt-, Neben-, Spuren- und Ultraspurenelementen ermöglicht. Über den Vergleich von Mikrofossileinschlüssen und Spurenelementkonzentrationen in Rohmaterial aus Baiersdorf und dem untersuchten Artefakt konnte eine zweifelsfreie Zuordnung zur Baiersdorfer Lagerstättenregion erfolgen.

STICHWÖRTER: Silexrohstoffe – Plattenhornstein Typ Baiersdorf – Silexherkunftsbestimmungen – Petrographie – LA-ICP-MS – Sichelblatt Typ Altheim – Imitation – Spätneolithikum/Kupferzeit – Niederösterreich

ABSTRACT: The Altheim type sickle blade (ca. 1st half of the 4th millennium BC) from Annastift-Krummnußbaum in Lower Austria represents the to-date most magnificent and completely preserved Neolithic harvesting tool of its kind in eastern Austria. The source of the raw material of this specimen manufactured from Jurassic tabular chert is located at Baiersdorf in the upper Danube region west of Regensburg, in northern Lower Bavaria (Germany), and was transported downstream the Danube Valley as a finished product. The sickle blade is placed in the Pfyn-Altheim-Mondsee cultural complex contemporary with the furrowed incised ceramic in Baalberge ceramic traditions and early Baden (Boleráz) in the middle Danube region.
Provenance studies were conducted according to the by now internationally established Multi Layered Chert Sourcing Approach (MLA). This method is based on a combination of macroscopic (visual), stereomicroscopic and geochemical

Received 15 March 2016; accepted 24 August 2016.

analyses. For geochemistry, Laser Ablation Inductively Coupled Mass Spectrometry (LA-ICP-MS) was applied which allows for the detection of main-, side-, trace- and ultra-trace elements. The comparison of microfossil inclusions and trace element concentrations from Baiersdorf raw material and the Annastift-Krummnußbaum sickle blade unequivocally established the origin of this artefact from the Baiersdorf chert source area.

KEY WORDS: Chert raw materials – Baiersdorf type tabular chert – Chert provenance studies – Petrography – LA-ICP-MS – Altheim-type sickle blade – Imitation – Late Neolithic/Copper Age – Lower Austria

INTRODUCTION

Over a half century ago, a completely preserved large chert sickle blade was found on an agricultural field west of the small village called Annastift (near the town of Krummnußbaum, Melk district), located on the right shore of the river Danube in Lower Austria (*Figure 1*). It was published shortly after its discovery by Reitinger (1968–70) and exhibited for a long time in the former Museum Melk a. d. Donau, before returned to its finder more recently. A few decades later it came into scientific focus again in the course of the investigation of Bavarian tabular chert *(Plattenhornstein)* finds in Lower Austria (Trnka *et al.* 2001, Trnka 2004: 319, Fig. 10), since there existed strong indications that it was produced from tabular chert from the Baiersdorf chert source in Lower Bavaria. During the Late Neolithic, specifically the Pfyn- and Altheim cultures (ca. 3800–3400/3300 BC), this tabular chert was widely distributed throughout Central Europe and popular for the production of the characteristic Altheim-type sickle blades (Drechsler 2012: 800–801). Over time, the Annastift-Krummnußbaum specimen became known as the most magnificent example of its kind in the easternmost distribution area of this artefact type and referenced by researchers from as far as Luxembourg (Le Brun-Ricalens *et al.* 2009: Fig. 7). To date, the artefact still represents a singular find without archaeological context, and recent examinations have also not produced additional finds; however, more extensive surveys are planned for the future in the larger surrounding.

In order to scientifically test the hypothesis of an origin of the raw material from the Baiersdorf tabular chert source, we investigated the artefact according to the MLA chert sourcing method and compared the obtained data with the results from earlier studies involving this characteristic lithic raw material. This undertaking was encouraged by the (analytically fortunate) circumstance that the piece broke into three parts recently and was delivered to the Institute of Prehistoric and Historical Archaeology (IPHA) of the University of Vienna for restoration.

MATERIAL AND METHODS

Typo-technological aspects

The object has been previously described in detail (Reitinger 1968–70: 1, Trnka *et al.* 2001: 242, Trnka 2004: 319, Fig. 10); however, we will provide the basic data here for completeness.

Metric data

Length 208 mm, max. width 62 mm, thickness 8–11 mm, weight 199.54 g.

Description

The Annastift-Krummnußbaum artefact (*Figures 2.1 and 2*) is a thin, light brown tabular chert blade with light brown natural surface (cortex) preserved on both sides. It has an elongated sickle-shaped form with a nearly straight cutting edge displaying distinct sickle gloss and an asymmetrically curved back; all lateral sides are carefully retouched. At the back adherent black spots and dots are visible, which were interpreted as possible tar remains already by Reitinger (1968–70, 1); however, without further analyses a secure determination of these remains cannot be provided at this stage of research.

According to Moser (Moser 1978: 52–54), there exist two main types of cutting implements produced from Baiersdorf chert plates: Double-edged curved knives or sickles with a length up to 30–35 cm and straight edged, oftentimes rhomb-shaped daggers and/or leaf points. Typologically, the Annastift-Krummnußbaum blade represents a sickle instrument with curved back, corresponding to the first of the above mentioned types.

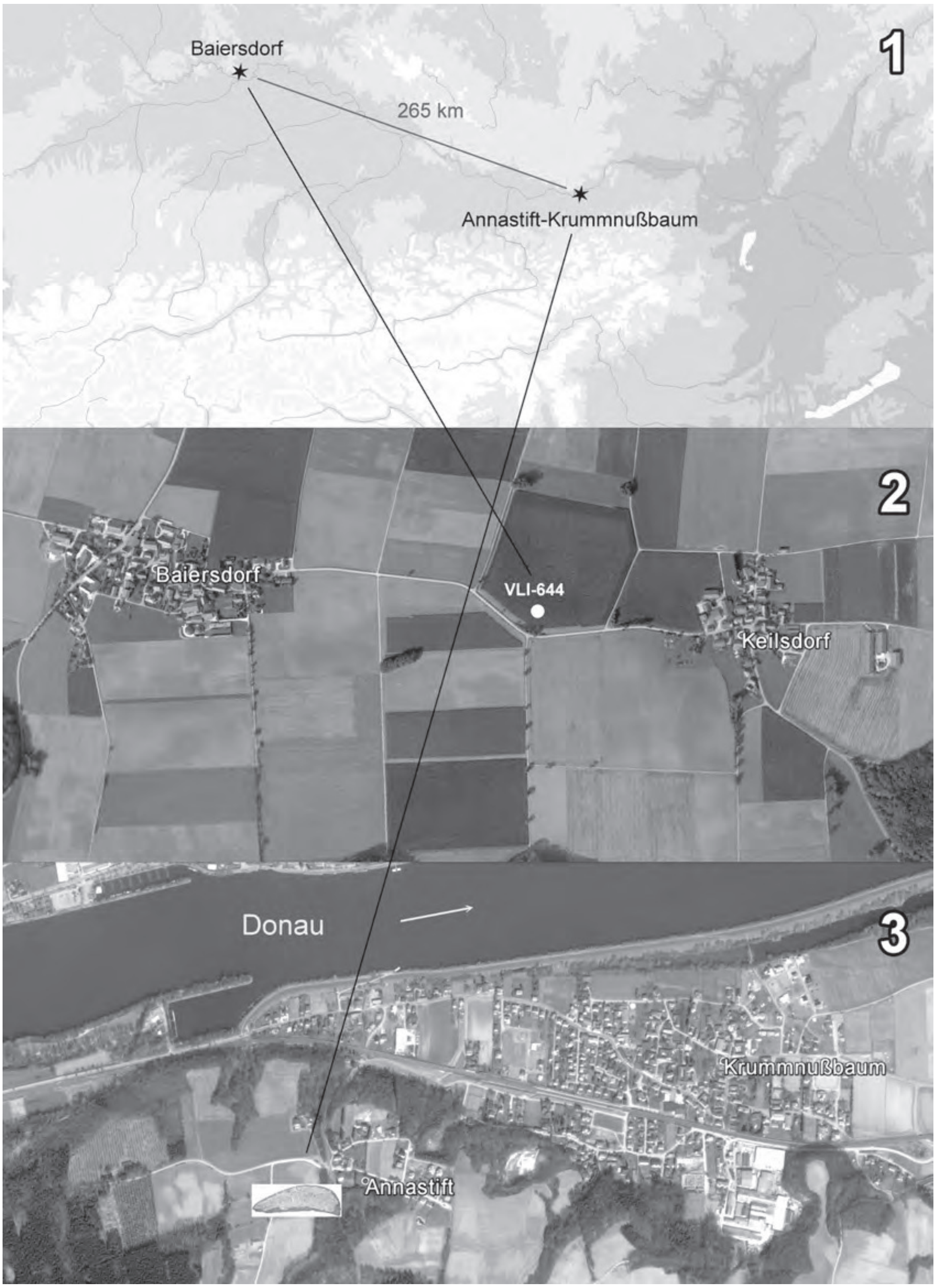

FIGURE 1. 1, Location of Baiersdorf (Lower Bavaria, Germany) and Annastift near Krummnußbaum (Lower Austria, Austria); 2, Baiersdorf (Google Earth 28. 9. 2014) – Comparative sample VLI-644 (27. 5. 2011); 3, Annastift near Krummnußbaum (Google Earth 25. 3. 2011). Find spot of the chert sickle from around 1964.

FIGURE 2. Annastift near Krummnußbaum (Lower Austria). 1, Photo G. Trnka; 2, From Reitinger 1968–70, Fig. 1 (not to scale); 3, Wooden handle from Gachnang-Niederwil (adapted from Müller-Beck 1991, 91, Fig. 82) with sickle blade from Annastift-Krummnußbaum inserted.

Analytical techniques

Due to the fact that the specimen was recently broken, it was possible to conduct raw material analyses on fresh rock parts. The method used for raw material and provenance determination follows the so-called MLA (Multi Layered Approach) for chert sourcing encompassing the following analytical steps.

Macroscopic

Any raw material study has to commence at the macroscopic level, recording and describing characteristic properties of the specimen(s) under investigation. Macroscopic groups can thus be defined, which have to be tested for consistency applying more detailed analyses such as microscopy and petrography/geochemistry (e.g. Ludtke 1992, Brandl *et al*. 2014, Bustillo *et al*. 2009).

Reflected light microscopy

Main objective by investigation silicites under a stereomicroscope is the detection and determination of characteristic micro fossil inclusions (e.g., Přichystal 1984, Brooks 1989, Binsteiner 2006a, b, Brandl *et al*. 2014). Micropalaeontological studies help to identify or narrow down raw material sources or source areas, since specific fauna communities detected in members of the chert family allow for the reconstruction of the formation environment of such biogenic sedimentary rocks. For the present study, micropictures were produced from the unpolished rock surface at a fresh breakage under varying 20–40× magnification and water immersion.

Geochemistry

For geochemical analysis, LA-ICP-MS was applied with an Agilent 7500ce quadrupole ICP-MS unit at the Central Laboratory for Water, Minerals and Rocks, NAWI Graz (University of Graz and Graz University of Technology, Austria) with sample introduction via an ESI NWR-193 laser ablation system. In order to avoid effects altering the chemical composition of sedimentary rocks ("patination") three discrete locations were measured at the fresh breakage in the "core" of the archaeological artefact, far from the present-day surface. The laser was operated at 75 µm spot size, 10 Hz pulse frequency and ~8 mJ cm^{-1}. The ablated material was transported via helium gas stream into the mass spectrometer, and passed into the ICP-MS unit. The standard reference glass NIST SRM 612 was routinely analyzed for standardization and drift correction (concentrations from Jochum *et al*. 2011). NIST SRM 614 was analysed as unknown in order to allow reproduction within 10 % relative error. Silicon (Si) was used as internal standard. A value of 99 wt % for Si was used for data reduction in GLITTER (GEMOC). The detection limit of LA-ICP-MS is typically 0.1 ppm for most elements, however the analytical error increases significantly with values below 1 ppm.

Results

Since a provenance of the Annastift-Krummnußbaum sickle blade from the Baiersdorf chert source was repeatedly suggested, raw material investigations focused primarily on this material in order to provide an analytical verification or falsification of this hypothesis.

The Baiersdorf chert source

Geographic setting

The extensive Kelheim/Regensburg area, also referred to as "Altmühl Alb", is a well-established prehistoric chert quarrying district in Lower Bavaria with the Baiersdorf chert source situated at the so-called Franconian Alb (Binsteiner 1989: 331, Fig. 1). At this locale, tabular chert occurs at one of the Upper Jurassic basins in the southern Franconian Alb, the so called Paintener Wanne. The prehistoric mining district covers some 35 hectares at the upper part of a shallow ridge located between the villages of Baiersdorf and Keilsdorf about 25 km west-southwest of Regensburg.

Geology

The Franconian Alb can be considered the continuation of the Swiss and French Jura Massives, extending for about 400 km between the Schwarzwald in the southwest and the Frankenwald region around Bayreuth in the northeast. It is characterised by a scarp-and-vale topography and locally steep limestone cliffs. Instead of the internationally established division in Lower-, Middle- and Upper-, the Jurassic period is here divided into "Schwarzer" (Black), "Brauner" (Brown) and "Weißer" (White) Jura (Binsteiner 2005: 44–45). Additionally, these stages are subdivided form α (alpha) to ζ (zeta), which in some cases are again sub-numbered. Geological formations of Jurassic age are defined by the epochs Lias, Dogger and Malm. Massenkalke of the Kelheim facies form the base of the Paintener Wanne basin. They are overlayered by loamy units of Neogene age referred to as "Albüberdeckung". Within the stratigraphically upper parts of the Albüberdeckung occur packages of residual tabular cherts ("Sandwich-plates") and rarer chert nodules formed during Malm ζ according to the local terminology, which corresponds to the conventional Upper Jurassic stage of the Thitonian (Moser 1978: 45–50, Binsteiner 1989: 331–332, Binsteiner 2005: 54–55).

Baiersdorf tabular chert

Macroscopic description

Baiersdorf chert plates typically range between 10 and 30 mm in thickness. The natural colour can show significant variation, and vary between creme coloured-beige, light brown and bluish-grey. Rarely, a deep yellowish-brown colour is observed which can be assigned to secondary impregnation due to depositional circumstances.

Binsteiner (2005: 55) distinguishes two types of Baiersdorf chert based on the coloration: Type 1 is whitish-grey to blueish-grey, and type 2 is whitish-grey to grey-brown with common streaking effects. Irregular banding and speckling are also common, however, a regular banding as observed at Arnhofen chert plates do not occur. The natural surface (cortex) of Baiersdorf chert is sandy, coarse and yellowish-white, covers both sides of the plates and can be several mm thick. Macrofossils, e.g. broken shells and remains of brachiopods and echinoderms, can be included into this cortex layer. The difference between the upper and bottom sides is distinct. Regularly, the upper side is auburn coloured and smooth, in contrast to the bottom side which is rougher and oftentimes of warty-cavernous appearance. The edges of Baiersdorf chert plates are typically sharp and splintery. At the Baiersdorf source chert nodules can also occur, however, they are much rarer than the chert plates. Nodules can reach diameters up to 300 mm, however the majority does not exceed 100 mm.

Microscopic description

Due to diagenetic processes, tabular Baiersdorf chert is generally scarce in clearly assignable fossil inclusions. Microfossils are accumulated towards the natural surface of the chert plates (Binsteiner 2005: 98). In the course of previous studies, only few unidentifiable remains of marine organisms with grain sizes ranging from 5 to 20 μm and marine detritus were documented (Brandl *et al*. 2011: 58). Identifiable fossils are remains of marine sponges, shells and echinodermata, and in rare cases sponge spicules.

Mineralogical/petrographic characterisation

In the course of XRD analysis, only quartz was detected at tabular cherts from Baiersdorf which consist of micro-crystalline quartz in a micro-granular pattern. In the cortex of some chert plates small amounts of carbonates (calcite) can be present (Brandl *et al*. 2011). However, XRD analysis did not provide conclusive results for a secure source assignment and was thus not included into the present study.

Geochemical analysis

Trace element analyses applying Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) were conducted for an initial case study differentiating Baiersdorf and Rein Basin chert at the University of Graz (Brandl *et al*. 2011). From 22 chert samples measuring 2 × 2 mm on average, data of 22 trace elements were collected in the course of this project, however, only lithium (Li), boron (B) and to a lesser extent aluminium (Al), titanium (Ti), vanadium (V), strontium (Sr), rubidium (Rb), copper (Cu) and zinc (Zn) were found to be useful in distinguishing samples from Rein and Baiersdorf. Trace elements displaying values below 1 ppm and colouring cations, i.e. iron (Fe), manganese (Mn), chromium (Cr) and nickel (Ni), were not used for provenance studies. For the present study, 10 elements from the initial data set could be utilised for a source assignment of the Annastift-Krummnußbaum artefact.

Raw material of the Annastift-Krummnußbaum artefact

Macroscopic description

The raw material of the Annastift-Krummnußbaum sickle blade is a tabular chert of honey-yellow brownish colour with a sandy-yellowish artificially abraded cortex. Macro-fossil inclusions are not present, and there is no visible banding or lamination detectable.

The "core" of the artefact could also be examined due to the fact that the specimen was recently broken into three pieces. The intense honey-yellow colour is consistent throughout the chert plate.

Microscopic investigations

Stereomicroscopic investigations revealed small remains of marine organisms, some heavily fragmented shells, and rarely sponge spicules (*Figure 3*). When compared to general inclusion patterns observable at micropictures from Baiersdorf chert samples (*Figure 4*), the strong similarities become apparent. The only difference is the sharp contrast in the yellow coloration of the Annastift-Krummnußbaum artefact versus the

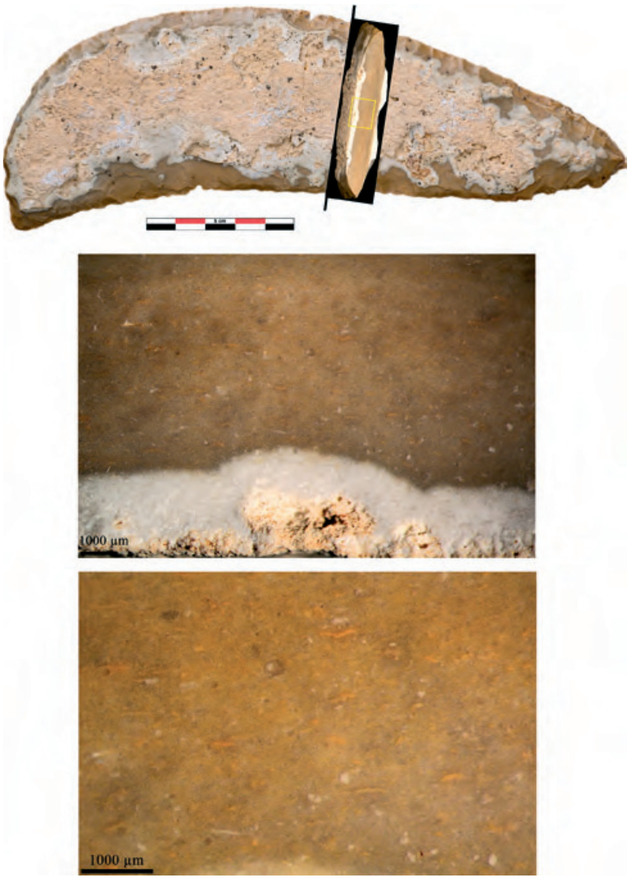

FIGURE 3. Annastift near Krummnußbaum (Lower Austria). Macro- and Microphotos (M. Brandl).

regular Baiersdorf material, however, it has to be noted that similarly yellow-brown coloured chert plates were recorded from the Baiersdorf source (*Figure 4*).

Geochemistry

Geochemical data of 42 elements were collected from the Krummnußbaum sickle blade, however, only 17 elements displayed values suitable for provenance studies. In order to test the consistency of the geochemical dataset of the Krummnußbaum sickle blade with data from the Baiersdorf source, we contrasted the 10 suitable elements from our initial study differentiating Baiersdorf and Rein chert (Brandl *et al.* 2011) against the same set of elements from the Krummnußbaum artefact. These elements are lithium (Li), boron (B), magnesium (Mg), aluminium (Al), titanium (Ti), vanadium (V), copper (Cu), zinc (Zn), rubidium (Rb) and strontium (Sr).

Binary (xy) plots reveal the high consistency of the Krummnußbaum data with those derived from the Baiersdorf samples as demonstrated by the Al–Mg, Al–Ti, Li–B and Sr–V concentrations (*Figure 5.1–4*).

Our geochemical results also contribute to the answer of the question of the intense yellow-brown coloration of the Krummnußbaum artefact: Iron (Fe) and manganese (Mn) values of the sickle blade are extremely elevated compared to those measured at fresh Baiersdorf material (Fe typically between 15 and 400 ppm, Mn between 2 and 20 ppm, averaged values from the Krummnußbaum artefact: Fe 2100 ppm, Mn 1700 ppm). Hence, it is possible that the artefact was impregnated during deposition in iron- and manganese rich environments for a significant time period. However, since similarly coloured raw plates are known from Baiersdorf, it is also possible that the sickle blade was produced on such a yellow-brown raw piece.

FIGURE 4. Baiersdorf (Lower Bavaria). Comparative sample 27. 5. 2011 (VLI-644). Macro- and Microphoto (G. Trnka, M. Brandl)

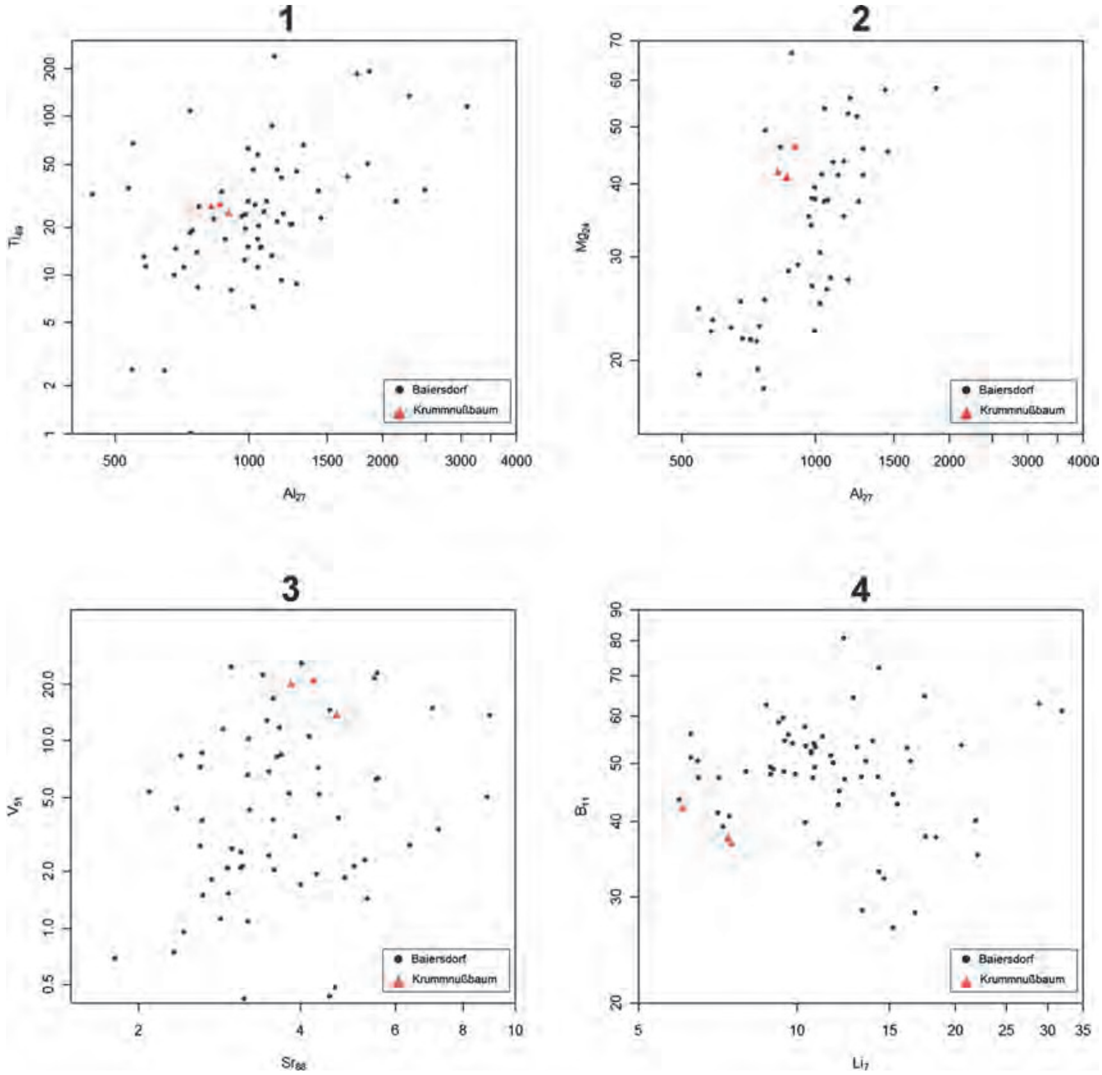

FIGURE 5. 1, Aluminium (Al) versus magnesium (Mg) concentration plot of the Baiersdorf chert samples and the Krummnußbaum artefact; 2, Aluminium (Al) versus titanium (Ti) concentration plot of the Baiersdorf chert samples and the Krummnußbaum artefact; 3, Lithium (Li) versus boron (B) concentration plot of the Baiersdorf chert samples and the Krummnußbaum artefact; 4, Strontium (Sr) versus vanadium (V) concentration plot of the Baiersdorf chert samples and the Krummnußbaum artefact.

DISCUSSION

Chrono-cultural assignment

Typologically, the Annastift-Krummnußbaum sickle blade shows closest similarities with chert sickles from Altheim culture contexts. Consistently, the prevailing lithic raw material utilized for the production of those chert sickles is Baiersdorf tabular chert. Larger find complexes of such flat bifacially retouched blades are recorded from the name-giving site of Altheim, the surroundings of Landshut and especially in the wetland settlement of Ergolding. Besides numerous singular finds and small assemblages in Lower- and Upper Bavaria the lake dwellings of the Mond- and Attersee, in the Nördlinger Ries and in Thuringia contain significant tabular chert assemblages produced from Baiersdorf raw material establishing direct connections with the Altheim culture and the Baiersdorf chert source. Isolated finds are known from Lower Austria in the Danube region and from tributaries, e.g. the Enns. Altheim-type sickle blades are also present in the context of neighboring cultures of the Final Neolithic from Switzerland over the Neckarland and the Rhine Main Area up to Franconia and Hessia, Lower Saxony and into Bohemia and Moravia (Binsteiner 2005: 134).

More recent studies have corrected previous ideas concerning a distribution of Baiersdorf chert into the south east alpine region (e.g. Styria at the Tesserriegel site or the hoard of Hengsberg near Schönberg) since a provenance of these chert artefacts could be established at the Styrian Rein Basin chert source (Brandl *et al.* 2014: 269–270).

How can the Annastift-Krummnußbaum artefact be culturally placed within the study area?

The southern Bavarian Altheim culture (ca. 3800–3400/3300 BC) belongs to the Pfyn-Altheim-Mondsee cultural complex, which extended from eastern Switzerland towards Upper Austria into the regions north of the Alps in central Europe. It can roughly be correlated with the early Baden culture, i.e. the Boleráz stage in the Middle Danube region, also corresponding to a horizon with furrowed incised ceramic (HFIC) or Baalberge, and can hence be placed within a context of the first half of the 4th millennium BC (Saile 2014: 37, Fig. 1).

A further argument for a correlation of this artefact type with the early Baden culture is indicated by the find

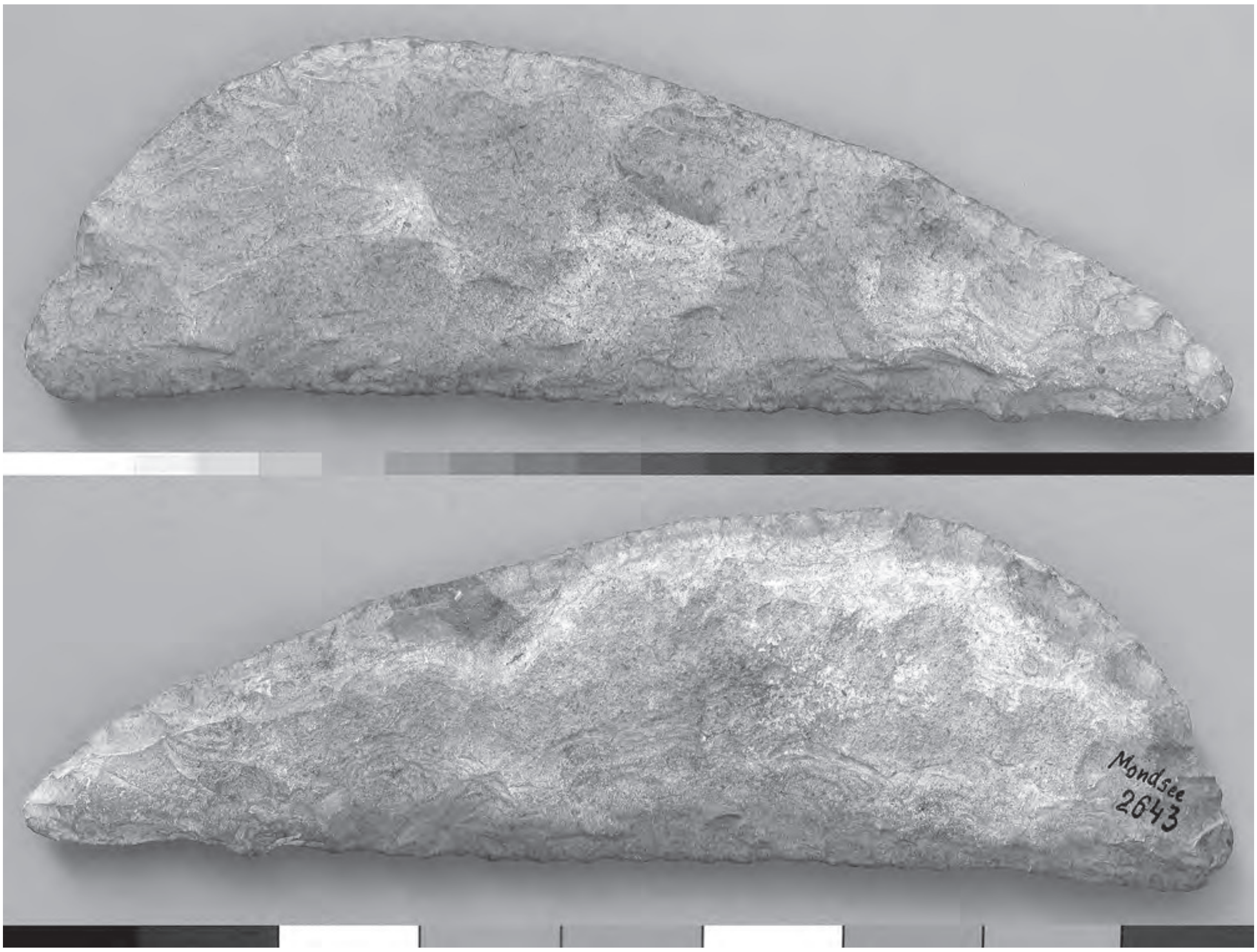

FIGURE 6. See am Mondsee (Upper Austria). Sickle blade. Spiculite (alpine chert). Collection Institute of Prehistoric and Historical Archaeology, University of Vienna, Inv.-Nr. 2643. Photo G. Trnka.

of a 189 mm long sickle-blade at Brno-Líšeň (southern Moravia), which is also made of the Bavarian tabular chert (Baiersdorf type). This sickle was excavated from a cultural layer dated by the presence of Boleráz type pottery (Medunová-Benešová 1979).

"Imitations"

An interesting aspect of Altheim-type chert sickle blades concerns "imitations" made from other (mainly local) raw materials than Baiersdorf chert. The investigation of the large chert assemblage (1,182 stone tools altogether) from the lake dwelling See am Mondsee revealed interesting details in this regard. Of 48 sickle blade shaped Altheim-type objects two third are manufactured from northern alpine spiculite (n = 32, see *Figure 6*), and only one third (n = 16) from Baiersdorf tabular chert, representing real imports (Binsteiner 2006a: 29, Tab. 3; 39, Fig. 16).

Hafting

Another important question is the hafting of Altheim-type sickle blades. Examples of different types of haftings from wood and antler are mentioned in Schlichtherle (1992: 33, Fig. 8.2).

For the Annastift-Krummnußbaum sickle blade, a find of a beech-wooden handle from the lake dwelling Gachnang-Niederwil (Canton Thurgau, Switzerland) (Hasenfratz, Raemaekers 2006: 45–46, Fig. 50; Müller-Beck 1991: 91, Fig. 82), which was dendrochronologically dated to ca. 3660–3585 BC corresponding to Pfyn (Hasenfratz, Raemaekers 2006: 23–24) is of specific interest. The handle is elongated and rounded, whereas the upper curved part in which the blade was inserted is oval shaped and deeply incised. This incision caused the breakage of one of the side parts, revealing the inner structure of the carving. In order to illustrate the way our sickle blade might have been once hafted, we fit the Annastift-Krummnußbaum artefact into the Gachnang-Niederwil hafting (*Figure 2.3*). This reconstruction also fits well with the cultural interpretation provided above.

CONCLUSION

Raw material analyses of the Annastift-Krummnußbaum sickle blade applying stereomicroscopy for micropalaeontological investigations and geochemistry using Laser Ablation Inductively Coupled Mass Spectrometry (LA-ICP-MS) confirmed the hypothesis of an origin from the Lower Bavarian Baiersdorf tabular chert source. Microfossil inclusion patterns and trace element concentrations correspond well with data gathered from Baiersdorf raw material during previous investigations. The intensive yellow coloration of the material can be either assigned to impregnation in the course of long-time depositional processes at the archaeological site or to the choice of an already yellowish-brown coloured raw plate as documented at the Baiersdorf chert source.

This extraordinary artefact can be queued into cultural traditions traceable throughout entire middle-central Europe during the Late Neolithic. Technologically and culturally, it has to be assigned to the Pfyn-Altheim-Mondsee chrono-cultural milieu, which can be equated with the Horizon of furrowed incised ceramic (HFIC) or Baalberge ceramic traditions and early Baden (Boleráz) in the Middle Danube region. This roughly corresponds to the timeframe of the first half of the 4th millennium BC.

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