This celebratory volume marks the 45 th year of collaboration between two great archaeologists of prehistoric Europe, Ryszard Grygiel and Peter Bogucki. It offers not only an admirable selection of papers by leading archaeologists on diverse topics pertaining to prehistory across Europe, but also a personal and social history of how Grygiel and Bogucki worked and developed intel - lectually in tandem, particularly through excavations at the well known Neo - lithic sites of Brześć Kujawski and Osłonki, Kuyavia. (...) What shines through the entire collection is the expansiveness of the honorees' joint and individual scholarship. Their work continues to provide a stimulating framework and source of research questions, addressed here through state-of-the-art tech - niques ranging from ancient DNA to philosophy of science.

From the review by Prof. Amy Bogaard (Oxford)

It is a kind of phenomenon that the book is dedicated to two scientists at the same time. In this case, it is fully justified. Ryszard Grygiel and Peter Bogucki were united not only by friendship but also by shared research interests. (...) From the beginning until now, the area of their activities is Kuyavia, a fertile lowland area on the left bank of the middle Vistula River. (...) The book Walking Among Ancient Trees is a proof of recognition from many outstanding specialists for the achievements of both jubilarians and of admiration for their cooperation, so close and undisturbed for decades. It is also an expression of gratitude for the many books and papers that have permanently entered the academic canon of our discipline.

From the review by Prof. Paweł Valde-Nowak (Kraków)

Edited by
Michał Grygiel
& Peter Obst

Walking Among Ancient Trees

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Fundacja Badań
Archeologicznych
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Konrada Jażdżewskiego

Fundacja Badań Archeologicznych
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WALKING AMONG ANCIENT TREES

Studies in honour of Ryszard Grygiel and Peter Bogucki
on the 45th anniversary of their
research collaboration

Edited by
Michał Grygiel & Peter Obst

Fundacja Badań Archeologicznych
Imienia Profesora Konrada Jażdżewskiego
Muzeum Archeologiczne i Etnograficzne w Łodzi

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Ryszard Grygiel and Peter Bogucki
during the Annual Meeting of the European Association of Archaeologists at the Europejska restaurant, Kraków, September 21, 2006 (Photo: Virginia Bogucki)

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Marshalltown trowel. One of the basic and reliable exploratory tools used during excavations in Brześć Kujawski and Osłonki (mentioned already in a first letter from Bogucki to Grygiel in 1976)



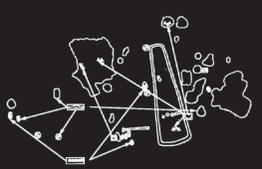
Peter Bogucki's indispensable tool for measuring osteological materials: a Vernier caliper made in Poland but purchased at a Sears store in Cambridge, Massachusetts, in 1978



Zoomorphic vessel (askos) of the Stroke-ornamented Ware culture from Dobre, Radziejów district (graphic motif on the cover of the successful book by Peter Bogucki Forest Farmers and Stockherders, Cambridge, 1988)



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The household cluster at Brześć Kujawski. Methodological concept introduced to Central European Neolithic studies by Bogucki & Grygiel



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Armlet included in a hoard from the older Bronze Age period discovered in Lgów, Jarocin district (research of Ryszard Grygiel on behalf of the Regional Museum in Jarocin in cooperation with Eugeniusz Czarny in 1974)



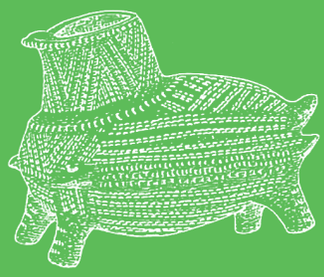
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Early medieval horse bridle splitter ring with Varangian-Ruthenian references discovered at the stronghold in Tum near Łęczyca



Medieval belt end fitting with a depiction of a pair of pelicans and a tree of life discovered at the stronghold in Tum near Łęczyca (research of Ryszard Grygiel, 2009)



Michael Brandl, Christoph Hauzenberger,
Peter Filzmoser, Gerhard Trnka

ŚWIECIECHÓW IN THE SOUTH – GEOCHEMICAL PROVENANCE OF A "FLINT" AXE FROM AUSTRIA

Provenance analyses of prehistoric far distance imports hold a great potential for tracing past human behaviour. This involves the reconstruction of trade and exchange networks revealing connections between different communities, and charting trends of raw material versus finished tool procurement at a macro scale. Especially lithic materials are ideally suited for such undertakings due to their abundance, durability and oftentimes wide distribution in the past. Here we demonstrate how the application of a multi-technique analytical procedure including stereomicroscopic microfacies analysis and geochemistry using LA-ICP-MS enables a clear assignment of the so-far only known Świeciechów silicite (flint) axe head from Austria to its source location over 500 km to the northeast in the central Polish Holy Cross Mountains. Our study also provides new geochemical data on the eponymous white spots for which this silicite is best known. Our geochemical results contribute to the already impressive body of knowledge about this unique raw material type, which can be regarded as one of the most important for prehistoric – and predominantly Neolithic – chipped stone production for large scale distribution.

The study of prehistoric resource management is one of the most promising and at the same time challenging endeavours to trace past human behaviour due to the oftentimes poor archaeological record. Therefore, stone tools are amongst the few suitable artefact classes for this task due to their abundance and durability. Amongst stone tools, suspected far distance imports are of particular interest since they can be used as proxies for the reconstruction of supra-regional contacts and distribution networks involving particular raw materials and objects.

As such, the stone axe discussed in this contribution represents an excellent example (Fig. 1). According to Ruttkay (1999, 44–45), the artefact was discovered in Schiltingeramt, a small village in northern Lower Austria at the beginning of the 20th century on an agricultural field without accompanying finds and lacking any further information regarding its exact find location. It is presently housed at the local museum in Langenlois (Inv. No. 96/2917), in the Krems-Land district. The slightly trapezoid-rectangular axe head is made from a characteristic raw material displaying a greyish groundmass with interspersed yellowish-white spots. This type of raw material is only known from the area around Świeciechów Poduchowny-Lasek at the middle course of the Vistula river in central Poland (Fig. 2) in the geological context of the Góry Świętokrzyskie (Holy Cross Mountains; A. Přichystal 2013, 109–110; A. Přichystal and L. Šebela 2004, 7–9, fig. 3), which are famous for the occurrence of a large variety of high quality silicites, most notably the so-called "chocolate flint" (e.g. A. Přichystal 2013, 108). Therefore, the stone axe from Schiltingeramt was macroscopically assigned to the region of Świeciechów already by E. Ruttkay (1999, 46; R. Seemann 1999). The importance of the Schiltingeramt artefact rests in the fact that it is the only known Świeciechów silicite ("flint")[1] axe from present day Austria (A. Přichystal 2013, 210; A. Přichystal and L. Šebela 2004, figs. 3:4, 5:3; L. Šebela and A. Přichystal 2020, 27; P. Włodarczak 2017, 315). It can however be connected to Moravia, where seven Świeciechów silicite axes have been recovered, and represents the to-date southernmost representative of these special objects (A. Přichystal and L. Šebela 2003, 152, figs. 7, 9:1, 5, 7; 2004, fig. 3:1–3; L. Šebela and A. Přichystal 2020, 26–27, map 4.5).

The distance between Schiltingeramt and the suspected source of the axe`s raw material – Świeciechów – is approximately 530 km as the crow flies, exceeding the distances of its Moravian counterparts, which range between 340 and 420 km. A clear connection between the Moravian Świeciechów axes and the piece under discussion is the morphological similarity of all specimens, which are more or less trapezoid with flake scars from shaping the roughout still visible on all sides of the axe and polishing only applied to the front (i.e. blade) parts (A. Přichystal and L. Šebela 2004, 18).

1. Chronology

Świeciechów silicite was used for chipped stone tools from the Middle Palaeolithic onwards through the Mesolithic and Neolithic periods until the early Iron Age (M. Szeliga and M. Huber 2016, 92). Up to now the widest distribution is recorded for the late Upper Palaeolithic (Magdalenian – c. 800 km; T. Wiśniewski et al. 2020, 281/4, fig. 1a). During the Linear Pottery Culture its furthest distribution extended 500 km to the southwest. The peak of its use falls into the Late Neolithic/Eneolithic periods, which is when the first axes made of Świeciechow silicite appear (B. Balcer 1971, 118; 1976, 190–195; B. Bargieł and J. Libera 1996, 37–38; A. Přichystal 2013, 109–110).

In the south-westernmost distribution area along the Danube in southern Moravia and north-eastern Lower Austria, evidence for chipped stone tools made from Świeciechów flint is rather scarce. There exist isolated finds from the late Linear Pottery Culture (e.g. in Schletz-Asparn in northern Lower Austria) indicating its occasional use since the early Neolithic, however, in the succeeding Stroke-Ornamented Pottery Culture and Lengyel Culture Świeciechów silicites have not been recognised in either Moravia or Lower Austria (I. Mateiciucová 2008, 64–65, 105, 131–132, 183, 187, tables 11, 16). In Moravia, seven Świeciechów silicite/flint axes have been discovered, amongst those one piece from a grave in Bezměrov (grave 18; L. Šebela and A. Přichystal 2020, 26–27, 91, pl. 2:1, photo 171). This axe head displays a slightly pointed back in contrast to the typical trapezoid shape, but still fits into the morphological spectrum. All Moravian Świeciechów axes are associated with the Corded Ware Culture (A. Přichystal and L. Šebela 2004, 18).

Consequently, the axe from Schiltingeramt can be best correlated with examples from the Corded Ware Culture based on typological and

[1] Although the term "flint" should – in its strict sense – not be used for this type of material, this is the accepted terminology in the archaeological literature. Therefore, we also use it in this study.

chronological criteria (E. Ruttkay 1999, 49–51). Potentially, it could also belong to the Funnel Beaker Culture, however, our current knowledge particularly regarding the use of specific stone tools such as flint axes during this time period is too limited in the north-western part of Lower Austria north of the Danube (the so called "Waldviertel"). Another possibility is the late Jevišovice Culture, which is strongly represented in this region (A. Krenn-Leeb 2004, 128; E. Ruttkay 1999, 51).

2. Previous studies

Despite the significance of Świeciechów flint as raw material for chipped stone tools (e.g. B. Balcer 1971; 1975; 1976; A. Přichystal 2013, 109–110; I. Mateiciucová 2008, 64–65, 105, 131–132; M. Szeliga 2014; and further references therein), there exist only few detailed petrological/mineralogical and geochemical studies. First discovered and described according to macroscopic (visual) features by J. Samsonowicz and S. Krukowski (see A. Přichystal 2013, 110), petrography was performed by O. Juskowiak (in B. Balcer 1976, 180) followed by A. Přichystal (2013, 110) who came to similar results. Świeciechów flint was included in the geochemical study by A. Högberg et al. (2013), who compared Scandinavian and Polish flint varieties. They used non-destructive energy dispersive X-ray fluorescence (EDS-XRF) and found some possibilities for a differentiation, however the sample number was too low for enhanced statistical evaluation. The so-far most detailed characterisation was produced by M. Szeliga and M. Huber (2016, 92) combining thin section and SEM analyses.

3. Aims of this study

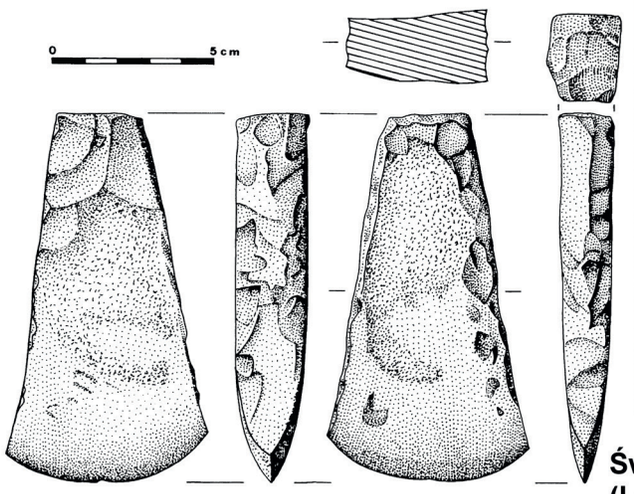
Although there is a plethora of literature on the characterisation and provenance information of Świeciechów flint, high resolution geochemistry has not yet been undertaken. For example, M. Szeliga and M. Huber (2016, 95) explicitly call for geochemical analyses of this particular material to "broaden the scope of research with more samples and additional chemical analyses (e.g. ICP-MS), aimed at more precise specification and quantification of the admixture of various minerals." Therefore, the primary goal of

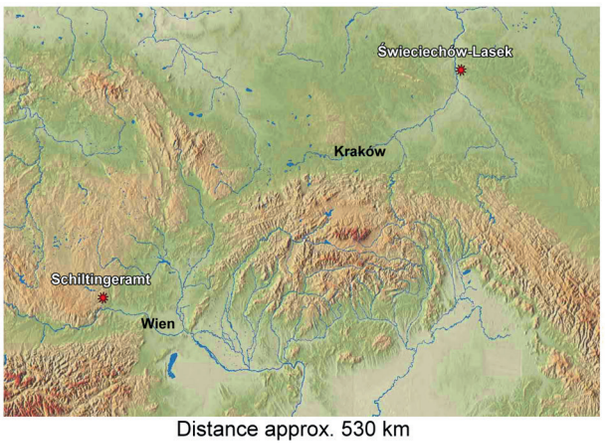


Schiltingeramt (Lower Austria). Square Axe (Świeciechów Flint). Length 11.4 cm, greatest thickness (neck area) 2.7 cm, thickness (middle area) 2.15 cm, cutting width 6.1 cm, neck 2.6 x 2.15 cm, weight 200 g.

Fig. 1. Świeciechów flint axe from Schiltingeramt (Austria). Photo Gerhard Trnka

this study was the geochemical characterisation of raw material from the locus typicus of Świeciechów flint at Lasek, and to assess the probability of an origin of the axe from Schiltingeramt from this area through refined statistical testing. The resulting data can be used by other researchers working in this area as a foundation to establish a deeper understanding of geochemical processes involved in silicite formation in particular regions of the Holy Cross Mountains in central Poland.

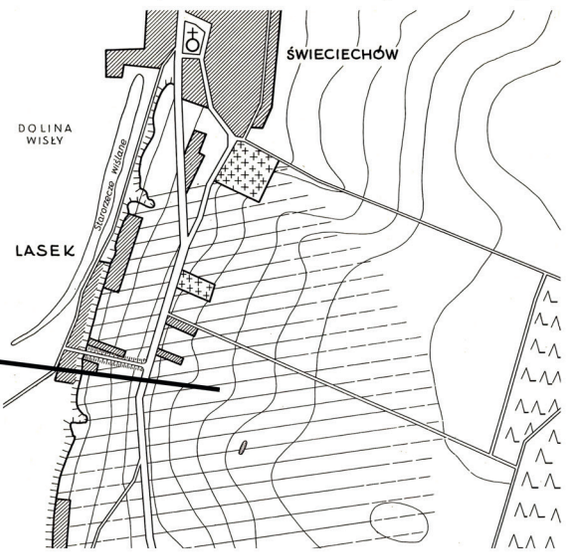




Świeciechów Flint Axe from Schiltingeramt (Lower Austria). After E. Ruttkay 1999, Fig. 2.



Swieciechów-Lasek (Google Earth 2017).



Swieciechów-Lasek (after B. Balcer 1971, Fig. 2 modfied).



■ Fig. 2. Flint axe from Schiltingeramt (Austria). Świeciechów Poduchowny-Lasek (Poland) – Sample VLI 820 (24.8.2000). Świeciechów-Lasek from the South 23.4.2013 (Photo Gerhard Trnka). Map base Inna Mateiciucová

4. Geology

The Holy Cross Mountains (HCM) are rich in high quality lithic raw materials extensively used for chipped stone tools, e.g. the famous "chocolate" silicites and several varieties of Turonian flints or silicites. Turonian flints/silicites are bound to a narrow, roughly 250 km long stripe along the north-eastern margin of the HCM, represented by two tectonic structures of Mesozoic age divided by the Vistula river. These are the Tarłów ditch to the west, and the so called Rachów anticline on the right bank of the Vistula. In the course of the Lower Turonian (Late Cretaceous) transgression, marine carbonate formations (various limestones and marls) built up in this area, which produce a high diversity of silicites (flints) in particular localities. This situation resulted in the macroscopic definition of specific flint types, some of which are only known from spatially restricted areas. While some of these flint varieties, which typically occur in the form of well-developed nodules or horizontal layers, occur still embedded in their primary host rock, others were accumulated by weathering processes of the bedrock and formed secondary subsurface deposits. The latter were the primary targets of prehistoric raw material exploitation due to the ease of access and abundance of material (M. Szeliga 2014, 79–80; M. Szeliga and M. Huber 2016, 83–84; T. Wiśniewski et al. 2020, 281).

Within this geological setting, Świeciechów flint is linked to weathered Turonian limestones of the Rachów anticline accumulated in residual deposits. The largest and best documented deposit is located in Świeciechów Poduchowny-Lasek (Gmina Annopol, Kraśnik District, Lublin Voivodeship), while smaller outcrops can be found at Rachów Nowy and Wymysłów immediately to the south of the main source. Extensive mining activities were undertaken to extract this high quality raw material at all three locations from the Neolithic, predominantly during the Funnel Beaker Culture (B. Balcer 1971; 1975; 1976), to the early Iron Age, which is attested by huge amounts of chipping waste on the surface. Further away, small amounts of Świeciechów flint have also been reported from glaciogenic deposits in South Poland on the upper course of the Vistula river (e.g. at Zakrzów/Niepołomice and Ściejowice/Liszki – M. Szeliga and M. Huber 2016, 91–92).

5. Materials and methods

For the current study, 21 individual samples collected at Świeciechów-Lasek (Fig. 2 and 3, without sample 21) were used as geological reference materials. In previous studies we found a number of 15 to 25 samples – depending on the individual intra-source variability – useful to characterise a source location of silicite raw materials and collect sufficient data for a secure differentiation from other geological deposits following P.C. Weigand's et al. (1977) provenance postulate. The raw material of the rectangular flint axe from Schiltingeramt was then compared to the results from the geological samples.

For a characterisation and provenance analyses we employed the Multi Layered Chert Sourcing Approach (MLA; M. Brandl 2016; M. Brandl et al. 2018). This technique combines visual/macroscopic grouping with subsequent stereomicroscopic microfacies analysis and geochemistry applying Laser Ablation Inductively Coupled Mass Spectrometry (LA-ICP-MS). LA-ICP-MS allows quasi non-destructive simultaneous analysis of main- (1–100%), side- (0.1–1%), trace- (1–1000 mg/kg) and ultra-trace elements (<1 mg/kg), whereby c. 50 elements are typically analysed in chert and flint raw materials. Microscopic investigations were performed with a reflected light Zeiss SteREO Discovery.V20 Stereomicroscope with 10–150× magnification coupled with an Axiocam 305 color camera for microphoto documentation. All microphotos were produced under water immersion (A. Přichystal 1984) on unpolished rock surfaces.

For geochemistry, the laser unit at the NAWI Graz Central Lab Water, Rocks and Minerals, Graz University of Technology and Karl-Franzens University in Graz (Styria, Austria), was used. This is an ESI NWR193 with an Agilent 7500 ICP-quadruple Mass Spectrometer. The samples were ablated with a 193 nm laser pulsed at 7 Hz, a spot size of 75 µm and under 85% laser power corresponding to an energy of ~7 J/cm². Helium was used as carrier gas at ~0.8 l/min flow and data was acquired in a time resolved mode. The standard glass NIST612 was routinely analysed for standardization and drift correction. The reference glass BCR-2 was analysed as unknown and reproduced better than 10% relative error. Silicon (Si) was used as internal standard. Representative grains of the 21 geological samples from Świeciechów-Lasek together with one small chip (c. 1×1 mm) from the archaeological artefact were embedded into a resin mount and polished for LA-ICP-MS analysis. In order to control inherent heterogeneities in SiO2 rocks (silicites such as chert and flint), 3 individual spots were carefully selected for analysis on each sample.

Eventually, the geochemical data were statistically treated by Robust Principal Component Analysis (RPCA) to assess the relation of data points obtained from the Schiltingeramt axe to those from the geological samples.

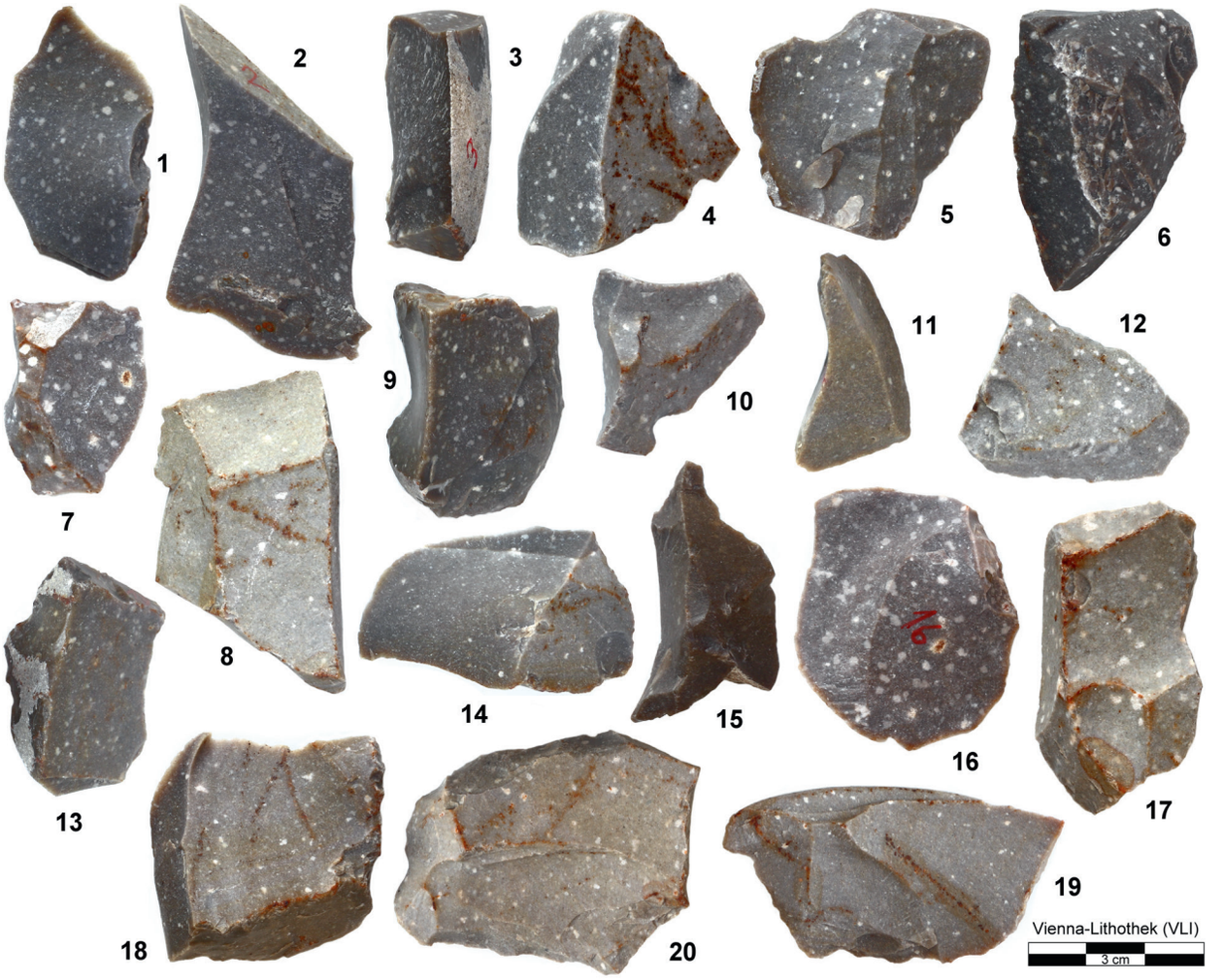


Fig. 3. Świeciechów-Lasek (Poland). Vienna-Lithothek. Samples VLI 820 – 1–20 (sampled 24.8.2000). Sample No. 21 not shown. Photo Gerhard Trnka

6. Results

In the following section we present the results of our macroscopic, stereomicroscopic and geochemical including statistical analyses of both, geological material from Świeciechów-Lasek and the investigated flint axe.

6.1. Macroscopic description

As described by M. Szeliga and M. Huber (2016, 92), one characteristic feature of Świeciechów flint are aeolised natural surfaces on shards of naturally broken nodules as well as on prehistoric chipping debris (e.g. large flakes). The colour variation of this raw material ranges between a light olive-grey to a darker grey, and both light and dark hues oftentimes co-occur in one nodule. The most characteristic trait however are sharply delimited yellowish-white spots in the grey groundmass, which define this particular raw material as "spotted Świeciechów silicite/flint" (Fig. 3). Although there exists no accessible primary outcrop of this material (B. Balcer 1976, 180–186), some cortex remains are preserved on the material from the residual deposits. It is typically thin and has a rough texture, displaying a white or slightly beige colour.

The macroscopic appearance of the flint axe from Schiltingeramt corresponds strikingly with Świeciechów raw material, which is why an origin of this piece from this source was assumed in the first place (E. Ruttkay 1999, 46–49).

6.2. Microscopic analyses

In previous studies using stereomicroscopy, thin sections and SEM analysis, predominant bioclasts were microscleres (sponge spicules) of

demosponges and foraminifers. Additionally, ore minerals such as pyrite and iron oxides, individual grains of carbonates, feldspar and glauconite were detected (A. Přichystal 2013, 110; M. Szeliga and M. Huber 2016, 92). The results of our stereomicroscopic analyses are in accordance with these findings as seen in Fig. 4. The preservation of the bioclasts is in most cases poor, they are heavily fractured and most microfossils only appear in the form of marine detritus.

The microfacies determinable through the arrangement, preservation, abundance and type of microscopic features (mainly the bioclastic components; see J. Affolter 2002, 40) for Świeciechów flint best corresponds to fossiliferous wackestone to packstone, indicating medium to high water energy as expected for rather shallow marine and reef environments (R.J. Dunham 1962; T. Wiśniewski et al. 2020, 281).

Stereomicroscopic results from the studied axe are identical to those from the geological comparative samples and show the same characteristic features (Fig. 4).

6.3. Geochemistry

In this study, 42 trace elements were analysed by LA-ICP-MS. These are lithium (Li7), beryllium (Be9), boron (B11), magnesium (Mg26), aluminium (Al27), silicon (Si29), phosphorus (P31), potassium (K39), calcium (Ca43), scandium (Sc45), titanium (Ti49), vanadium (V51), chromium (Cr53), manganese (Mn55), iron (Fe56), cobalt (Co59), nickel (Ni60), copper (Cu63), zinc (Zn66), gallium (Ga71), germanium (Ge74), rubidium (Rb85), strontium (Sr88), yttrium (Y89), zirconium (Zr90), niobium (Nb93), tin (Sn118), caesium (Cs133), barium (Ba137), **lanthanum (La139), cerium (Ce140), praseodymium (Pr141), neodymium (Nd146), samarium (Sm147), europium (Eu153), gadolinium (Gd157), dysprosium (Dy163), erbium (Er166), ytterbium (Yb172)**, lead (Pb208), thorium (Th232) and uranium (U238). Of these, highlighted elements are Rare Earth Elements (REE), for which concentration values of La, Ce, Pr, and Nd lie below1 mg/kg, whereas the series of elements between Sm and Yb lies below the detection limit. The concentration of the elements Li, B, Mg, Al, P, K, Ca, Ti, V, Fe, Ba were detected in concentrations well beyond 1 mg/kg.

Trace elements Li, B, Mg, Al, P, K, Ti, V, Fe and Ba are contained in various minerals and rocks in the Earth`s crust, and enter marine sediments in the course of continental weathering and subsequent fluviatile and/or aeolian transport. Eventually, they are concentrated particularly in clay minerals, phosphates and carbonates. Diagenesis, i.e. the process of sedimentary rock consolidation, also has a significant impact on the enrichment or depletion of certain trace elements (e.g. T. Ishikawa and E. Nakamura 1993; L.-H. Chan et al. 2006). In silicite materials, Al, K, and partly Sr can be related to feldspars and clay minerals. Carbonates are biogenic sediments and the primary constituents of the host rock facies of most silicites and incorporate a series of elements such as Mg, Sr and Ba. As such, these trace elements can be used as proxies for past bioactivity in marine environments (e.g. D. Smrzka et al. 2019).

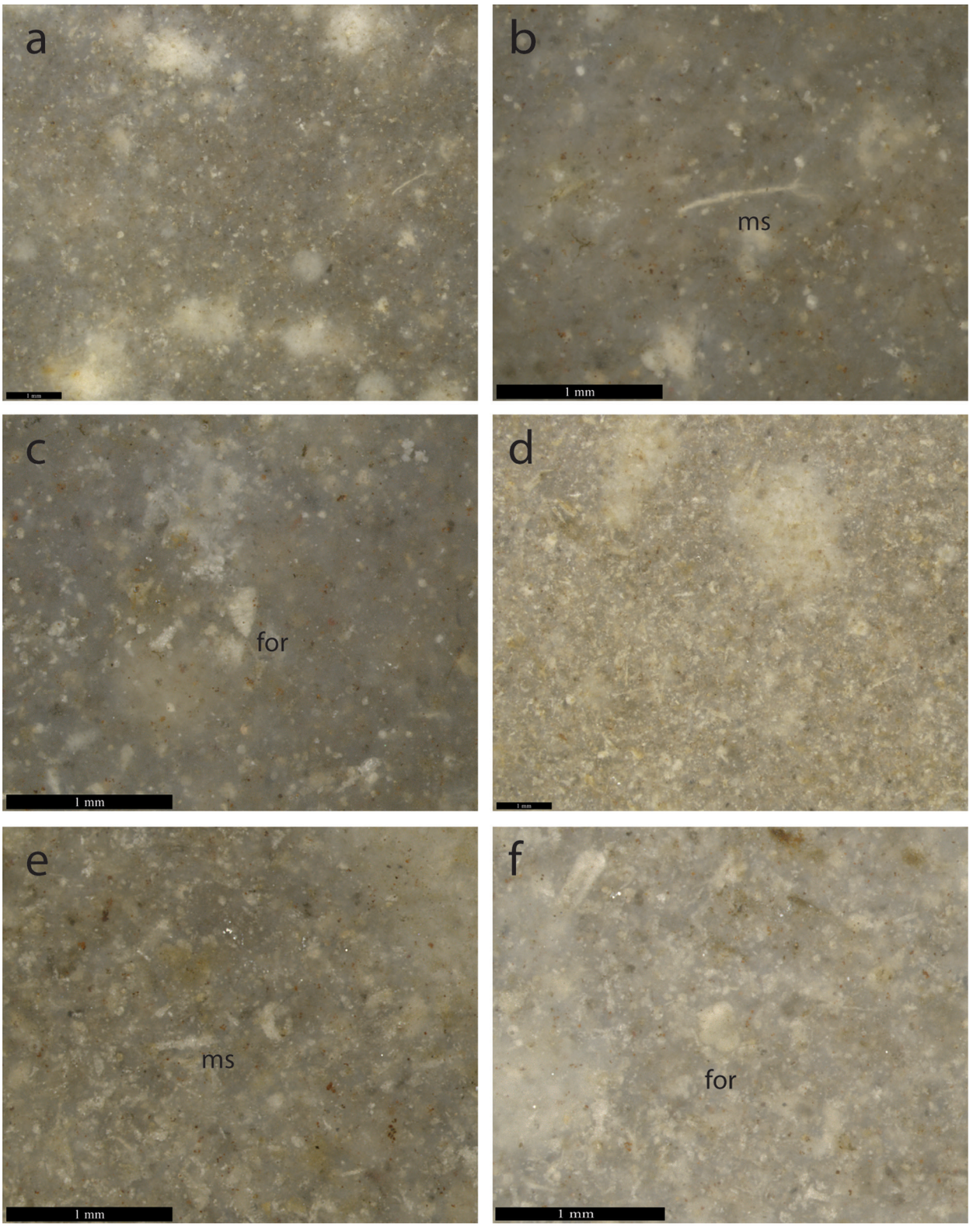
Additionally, correlations of specific elements (i.e. Ca, K, Mg and Sr) with Al reveal source-genetic conditions and mineral phases to which those elements are related (e.g. M. Brandl 2016; M. Brandl et al. 2011; 2014; 2018; G. Faure 1998). For the present sample series, these are predominantly clay minerals, carbonates and phosphates. The presence of clay minerals is confirmed by a strong correlation between Al (mainly between 400 and 1500, rarely up to 3000 mg/kg) and K (300–1800 mg/kg) (Fig. 5a). Rubidium (Rb), which behaves geochemically similar to K, displays a similar trend. Titanium (Ti) and Al also correlate and are attributed to clay mineral content. The majority of our investigated samples ranges between c. 200 and 5000 mg/kg in Ca, which only displays a weak correlation with Al indicating the presence of carbonates and not Ca-rich feldspar (Fig. 5b). This is substantiated by a correlation with Mg (c. 20–100 mg/kg, a few as high as 400 mg/kg) revealing dolomitic carbonates (Fig. 6a). Light rare earth elements (e.g. Ce) display a strong correlation with phosphorus (P) (Fig. 6b). Apatite, the most common phosphate, can be formed either by biogenic activity or in the course of diagenesis.

Strontium (Sr) content (the majority ranges between 2 and 7 mg/kg, few show higher values over 10 mg/kg) can be related to either of the aforementioned, clay minerals, carbonates and apatite.

6.4. Chemistry of the white spots

One question of particular interest concerned the characteristic eponymous yellowish-white spots in the SiO_2 matrix of spotted Świeciechów silicite. In the course of our LA-ICP-MS study, six random white spots were selected for analysis on samples No. 2, 7, 16, 20 and 21 to investigate their trace element concentrations.

Our findings are largely in accordance with previous studies (e.g. A. Přichystal 2013, 110; M. Szeliga and M. Huber 2016, 92), and offer deeper insights into this intriguing phenomenon. Compared



■ **Fig. 4.** Stereomicroscopic investigation of geological samples (GS: a–c) and the Schiltingeramt axe (SA: d–f). Microphotographs Michael Brandl. a: characteristic microscopic pattern of Świeciechów silicite with bioclasts and white spots; b: demosponge microsclere (ms); c: foraminifer (for); d: characteristic microscopic pattern; e: demosponge microsclere (ms); f: foraminifer (for)

to the silicite groundmass, the white spots are generally enriched in Li and in some cases additionally in Mg, Al, P, Ti, V and Zn, while they are at the same time depleted of B (Fig. 7a). Colouring cations Fe and Mn behave unsystematically and sometimes show higher and sometimes lower concentrations. Values for Ca, which was suspected to be primarily responsible for the formation of these features, was in most spots less concentrated than in the surrounding rock matrix with values below 1000

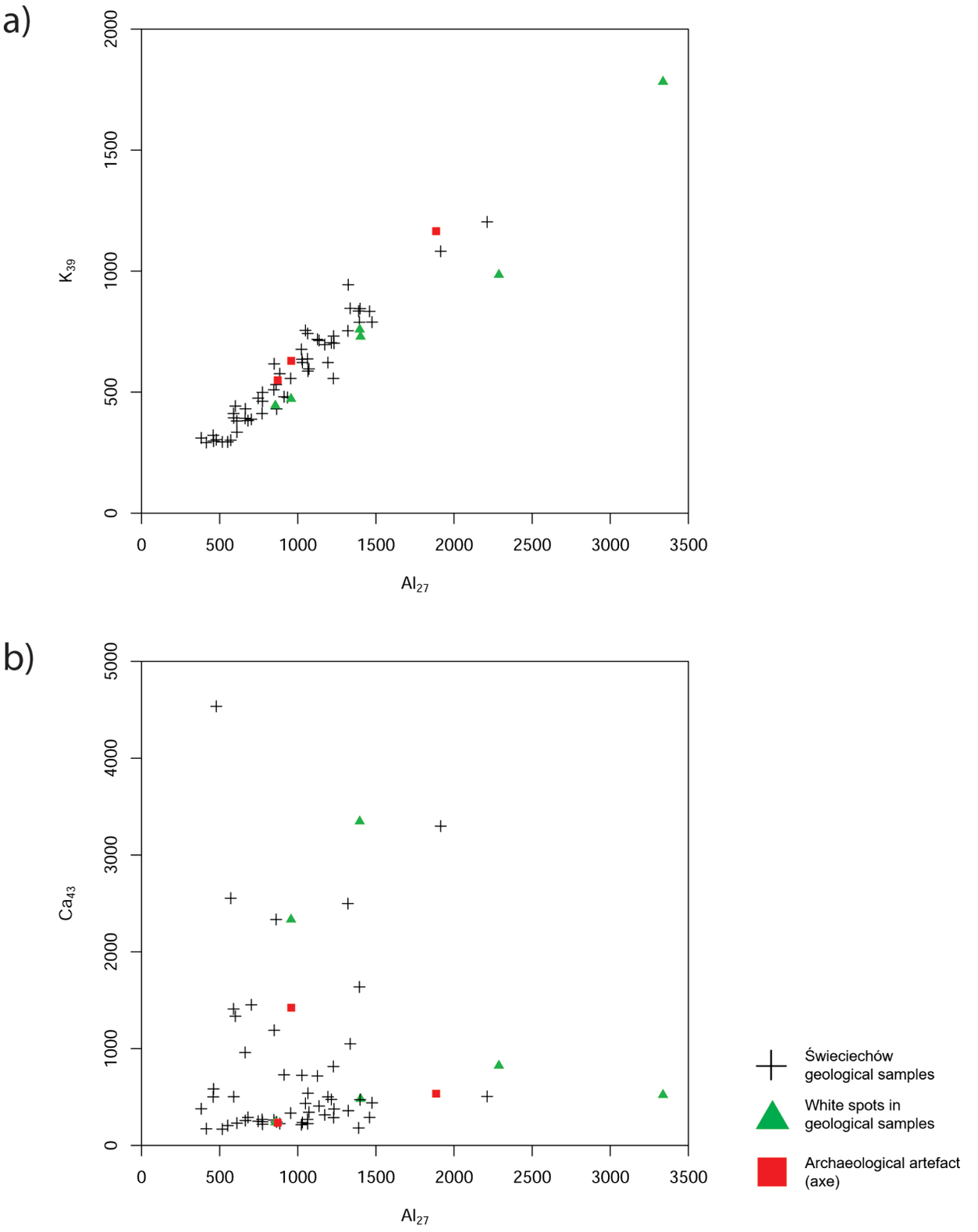


Fig. 5. Geochemical results; a: aluminium (Al) vs. potassium (K) concentration plot; b: aluminium (Al) vs. calcium (Ca) concentration plot. Graph Michael Brandl and Christoph Hauzenberger

mg/kg in four cases, and slightly over 2000 mg/kg and 3000 mg/kg in the other two. Therefore, the formation of the white spots in Świeciechów silicite appears to be the result of complex diagenetic processes specifically affecting these rock parts. These processes started at originally bioclastic (carbonatic/apatite) material, which was gradually replaced by silica, and eventually resulted in the accumulation or depletion of certain trace elements (e.g. Li and B).

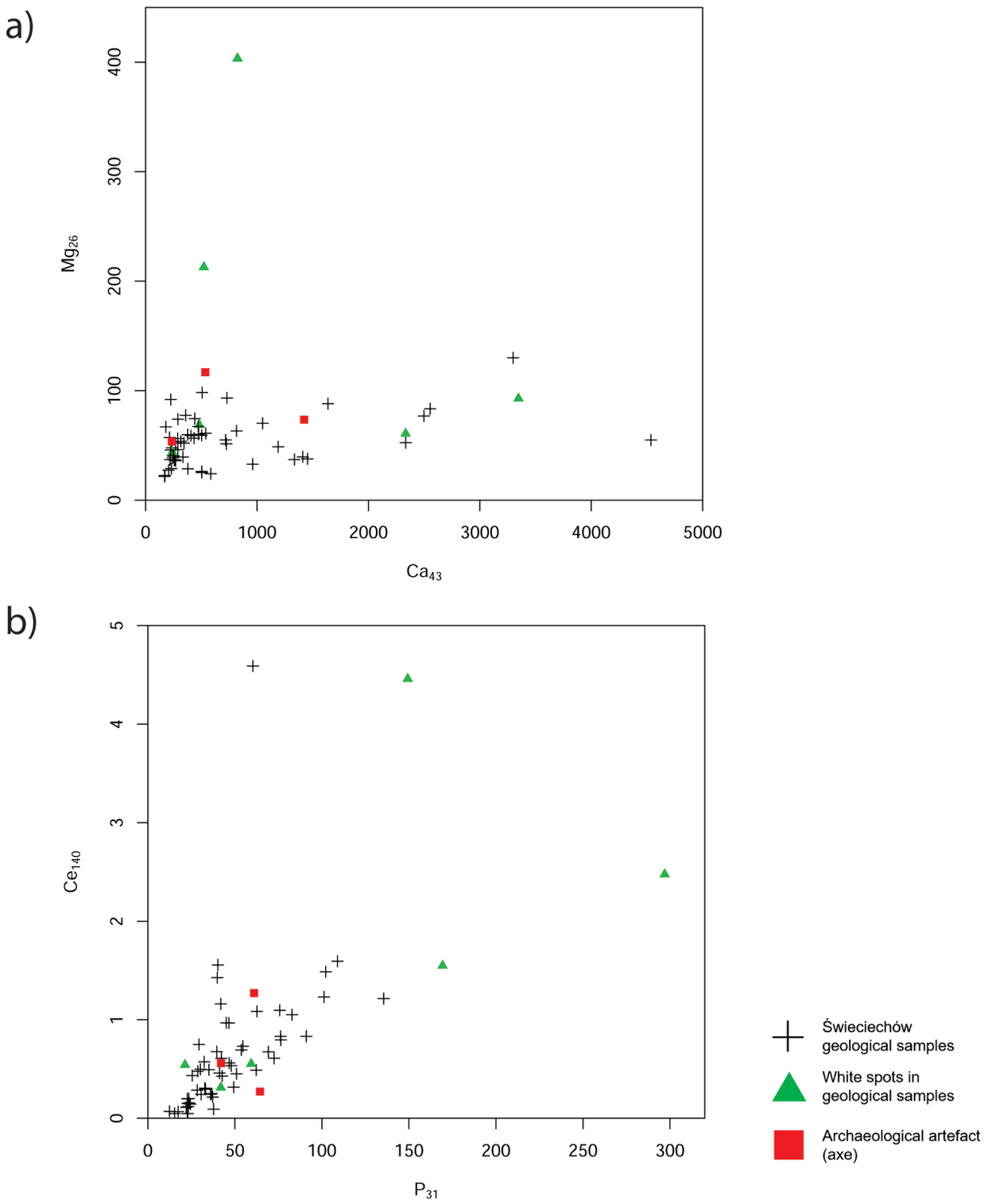


Fig. 6. Geochemical results; a: calcium (Ca) vs. magnesium (Mg) concentration plot; b: phosphorus (P) vs. cerium (Ce) concentration plot. Graph Michael Brandl and Christoph Hauzenberger

The identical set of chemical elements determined for the geological samples was analysed for the archaeological artefact under investigation. For testing the likelihood of the flint axe originating from Świeciechów, geochemical data were subjected to statistical evaluation.

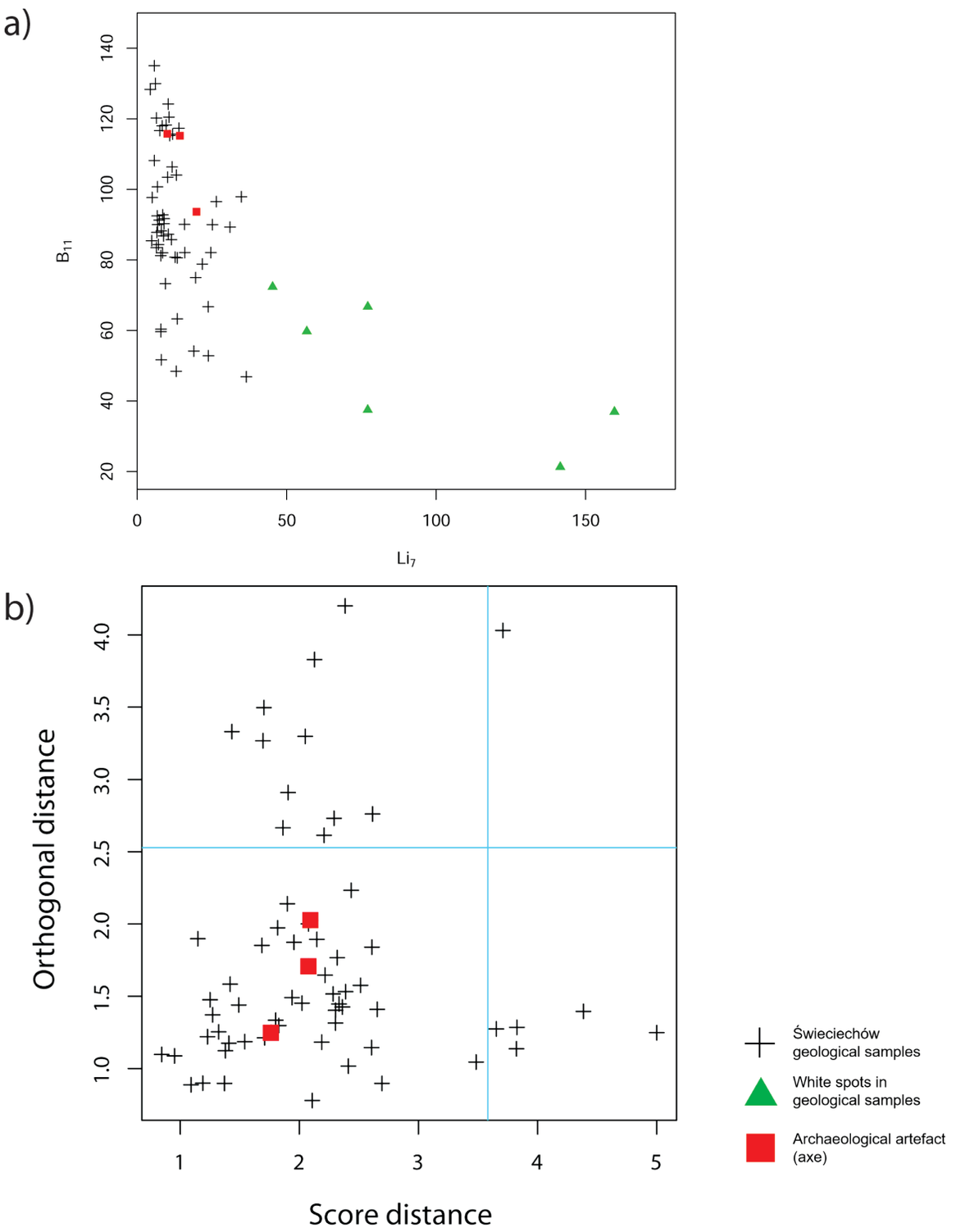


Fig. 7. Geochemical results; a: lithium (Li) vs. boron (B) concentration plot; b: RPCA "outlier plot" displaying orthogonal versus score distance of geological samples and the Schiltingeramt stone axe. Graph a: Michael Brandl and Christoph Hauzenberger; b: Peter Filzmoser

6.5. Statistics

After expressing the compositional data in log-ratio coordinates (P. Filzmoser et al. 2018), robust Principal Component Analysis (RPCA) was applied to the geological dataset and illustrated in a diagnostic outlier plot. The graph displays orthogonal versus score distance with the indicated raster lines as critical values. All data points outside the lower left quadrant appear as unusual when compared with the majority of samples. This highlights the intra-source variability of elemental composition within the geological samples, although all come from the same deposit.

Subsequently, the test data (i.e. the three data points acquired from the flint axe) were projected into this observation. The result places the archaeological dataset within the most characteristic geological data cluster and thus confirms the high probability of the artefact belonging to the dominating Świeciechów chemofacies (Fig. 7b).

7. Conclusion

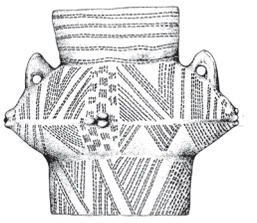
The flint axe from Schiltingeramt is the only known artefact of its kind ("Świeciechów flint") from Austria and therefore of particular interest for tracing far distance distribution networks during the Late Neolithic/Eneolithic which connected large parts of central Europe. Although the exact find location on an agricultural field in the village of Schiltingeramt in the Waldviertel area of northern Lower Austria cannot be verified, the techno-chronological connection with examples from Moravia places the Austrian flint axe in a plausible cultural framework. According to E. Ruttkay (1999, 50), this framework can be best identified with bearers of the Corded Ware Culture as the most likely candidates, with an additional (however less likely) potential for a connection with the Funnel Beaker Culture or the late Jevišovice Culture. It is however clear that this axe head, like all known pieces in the Austro-Moravian catchment area, came to the region already as finished product, which corresponds to a "continental distribution" pattern of over 400 km distance (I. Mateiciucová and G. Trnka 2015, 13).

The raw material was already suspected to originate from the area around Świeciechów in the Góry Świętokrzyskie (Holy Cross Mountains) in central Poland based on its characteristic visual appearance by E. Ruttkay (1999, 46; R. Seemann 1999). Although previous investigations have produced a sound petrological and mineralogical characterisation of this particular raw material type, which was widely used from the Middle Palaeolithic to the early Iron Age and distributed over 500 km distance during the Neolithic period, in-depth geochemistry was still lacking. Consequently, the primary goal of this study was the geochemical characterisation of this famed silicite (flint) from its locus typicus at "Świeciechów-Lasek" through trace element determination using LA-ICP-MS as one integral part of the Multi Layered Chert Sourcing Approach (MLA). Our results confirmed previous findings from petrographic thin section- and SEM-analyses, and revealed clay minerals, carbonates and phosphates incorporating trace elements, which are useful to reconstruct the formation processes and to characterise Świeciechów flint. In the future, these results can contribute to expand on the in-depth characterisation and provenance studies of silicites from the Holy Cross Mountain silicite bearing zone on a larger scale.

Finally, it was possible to unambiguously assign the flint axe from Schiltingeramt to the main geochemical Świeciechów data cluster through statistical treatment using Robust Principal Component Analysis (RPCA), which confirmed the initial assumption by E. Ruttkay (1999, 46) and R. Seemann (1999). Our future goal is a geochemical study using this geological dataset and including all suspected Świeciechów silicite/flint tools from throughout eastern Austria from Early to Late Neolithic and Eneolithic contexts to establish a sound database with the possibility to extrapolate diachronic use and distribution patterns of this particular high-quality lithic raw material.

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