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The Occurrence of Lithic Raw Materials in the Western Part of Central Germany

RESEARCH PAPER

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ABSTRACT

Due to its geological and geomorphological features, Central Germany is extremely diverse in terms of the occurrence of lithic raw materials. Based on macroscopic criteria alone, it remains challenging to unambiguously distinguish different rock types that were used for the production of stone tools in prehistoric times. Yet, only a few studies have presented a systematic description of the materials in question, including petrographic analysis. The following article presents the results of a research project, aimed at investigating the abundance of lithic raw materials in the Federal State of Hesse and adjacent regions. In the framework of field surveys, several outcrops in the study area were sampled in order to create a reference collection. These materials were analyzed and described petrographically, using optical microscopy. In combination with GIS-analysis, the results offer a robust starting point for the study of prehistoric mobility patterns and give new insights into the genesis of the various raw materials in the study area.

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INTRODUCTION

RESEARCH HISTORY

The study of lithic raw materials in the western part of Central Germany goes back to the work of the geologist Heinrich Richter in the 1920's, who directed archaeological excavations at several Middle Palaeolithic rock shelters near Treis a. d. Lumda (Richter 1925). He was the first to recognize the importance of regionally available silicified sandstone *(Tertiärquarzit)* for the production of stone tools by prehistoric people (Fiedler 1994: 86). Richter's discovery led to investigations in the vicinity of the raw material outcrops near Ziegenhain (Schwalm-Eder-Kreis, Hesse) by Luttropp between 1938 and 1939 (Luttropp 1949). During the following years, additional Middle Palaeolithic workshops, containing large numbers of stone tools made of silicified sandstone, were discovered. The sites and the respective raw material outcrops were described by Gerhard Bosinski (1967) as part of his PhD-thesis. Furthermore, a potential relation between different raw material types and the final shape of Middle Palaeolithic leafpoints was proposed by Lutz Fiedler (2010). An investigation of lithic artefacts found at the open-air sites Rüsselsheim a. Main (Loew 2005), Mühlheim-Dietesheim (Fruth 1994), and Rothenkirchen (Hofbauer 1992) gave new insights into the importance of different raw material types during the Late Palaeolithic. Excavations at the Mesolithic open-air site Feuersteinacker near Stumpertenrod between 1964 and 1966 yielded one of the largest Mesolithic assemblages in Germany (Krüger & Taute 1964; Fiedler 2017; Hess & Riede 2021).

Despite these advances, several authors have mentioned difficulties to distinguish lithic raw materials occurring in the study area based on macroscopic criteria alone (Taute, 1971: 19; Pflug 1993; Fiedler 2017: 3–4). A first in-depth petrographic analysis of lithic raw materials in the Rhön Mountains was conducted by Brigitte Pflug (1993). To the north of the study area, Klaus Grote (1993) has summarized the use of different rock types by Mesolithic hunter-fisher-gatherers in the Leine Uplands (Lower Saxony). In the Rhineland, the work of Harald Floss (1994) has increased the knowledge on the occurrence and the properties of lithic raw materials. An analysis of stone tools found at the famous Lower Palaeolithic open-air site Bilzingsleben led to a better understanding of the use of different rock types in Thuringia (Weber & Mania 1986; Weber 2013). Additionally, several recent studies are concerned with mobility patterns and raw material procurement strategies in the south and southeast (Sauer 2016; Spies 2017), and in the west (Gehlen et al. 2021) of the study area.

In the framework of an Early Postdoc.Mobility Fellowship funded by the Swiss National Science Foundation (SNSF) between 2019 and 2020, the use of lithic raw materials by Late Palaeolithic and Mesolithic groups in Central Germany was systematically analyzed. For this purpose, samples of the most important outcrops in the Federal State of Hesse and adjacent regions were collected, in order to establish a reference collection. At the same time, the entire lithic assemblages dating to the Late Palaeolithic and the Mesolithic present at the Hessian State Museum in Kassel were examined, with a particular focus on the sites Feuersteinacker in Stumpertenrod, Hattendorf, Bodes, and Rothenkirchen.

Having their roots in the antiquarian traditions of the 18th and 19th century, often linked with the emergence of museums of natural history, the establishment of geological collections with a focus on archaeological research questions has recently faced a revival (cf. Biró 2008). Geoarchaeological studies involving field surveys to build up reference collections were conducted in different parts of Europe during the past decades (e.g. Floss 1994; Tykot 1996; Přichystal 1997; Affolter 2002; Binsteiner 2005; Biró 2008; Högberg & Olausson 2007; Elburg & van der Kroft 2008; Bertola 2011; Burkert 2013; Sánchez de la Torre et al. 2014; Driscoll et al. 2016; Pereira et al. 2016; Delvigne et al. 2017). Comparitive collections allow to ascribe specific rock types to particular outcrops within a geographic area. Their existence is fundamental for a detailed classification of lithic raw materials in an archaeological context and plays an important role for the study of mobility patterns and social interactions in the past. Methodological advances in the field of material sciences (cf. Sieveking & Hart 1986) made it possible to combine different types of petrographic and geochemical analyses (e.g. Brandl 2016; Moreau et al. 2016; Abrunhosa et al. 2020; Sánchez de la Torre 2020). In the sense of an interdisciplinary and holistic approach, reference collections also give insights into the way in which human beings interacted with their environment (cf. Butzer 1982). Additionally, they help to understand the connection between physical properties of raw materials and technological aspects of stone tool production.

GEOLOGICAL OVERVIEW

The geomorphology of the study area is strongly influenced by low mountain ranges and river valleys. In the centre of the Federal State of Hesse, the Vogelsberg Mountain rises to an altitude of 773 m above sea level (***Figure 1***). The Tertiary basalt formations cover an area of around 2500 km^2 and are the largest volcanic structures in Central Europe (Fiedler 1997: 8; Reischmann & Schraft 2009: 9). Several rivers, including Ohm, Schwalm, Fulda, and Antrift, originate in the area and flow radially in different directions. The borderland between Hesse, Bavaria and Thuringia is characterized by the Rhön Mountains. To the west, there is the Rhenish Massif, including the Taunus and the Kellerwald. It consists mainly of sedimentary rocks—such as sandstones and shales—that were deformed and partly metamorphosed during the Hercynian orogeny. Their highest parts are

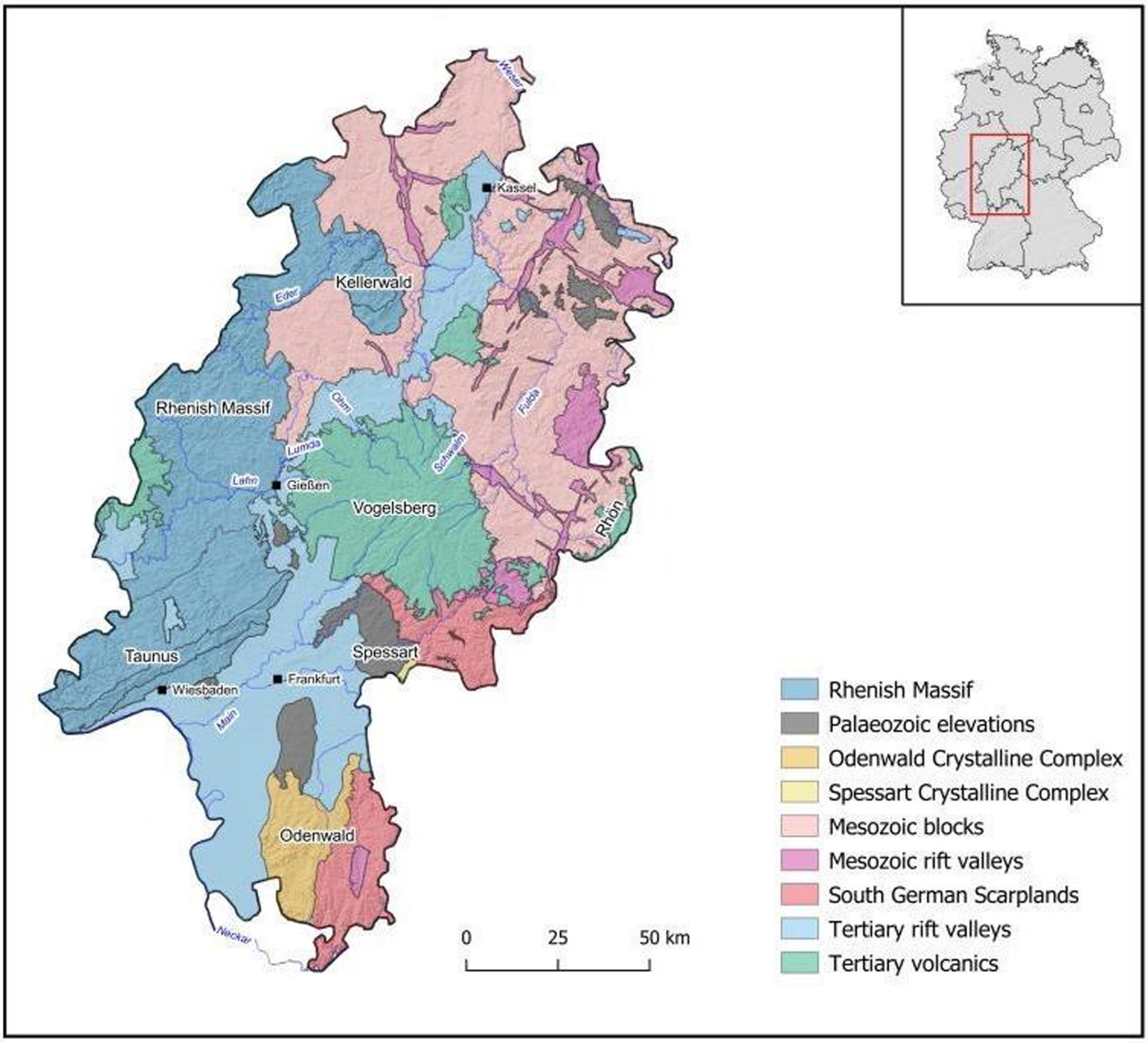

Figure 1 Geological map of the study area. Source: HLNUG (Figure: T. Hess).

the Rothaar Mountains where the river Eder rises. The Odenwald and the Spessart Crystalline Complexes that were covered by sedimentary rocks during the Triassic, mark the southern border of Hesse (Lotz 1995: 29). In the opposite direction, the Northern Lowland adjoins the study area. Loess soils occur within Tertiary rift valleys that run from the bottomland of the river Weser to Lower Hesse. In the southern part of the region, the river Main—that provides an important connection between east and west—joins the Rhine near Mainz. Similarly, the river Neckar links Southwestern Germany with the central part of the country.

MATERIALS AND METHODS

The sampling of important raw material outcrops in the study area was conducted between spring and autumn 2019. Beside geological maps and reports (Rösing 1976; Lotz 1995; Thews 1996), as well as existing literature on the topic (Krüger & Taute 1964; Pflug 1993; Grote 1993; Fiedler 2017), Late Palaeolithic and Mesolithic assemblages at the collections of several museums formed the starting point for the field surveys. Each outcrop was documented photographically and the coordinates were measured with a handheld GPS-device. The reference collection was complemented by samples from the collection of the Hessian State Museum in Kassel. So far, it comprises 25 different rock types, including primary sources as well as secondary deposits, such as alluvial terraces. The origin of the samples and the geological formations in which they occur were visualized using a GIS template. For this purpose, existing geological maps were adapted to the specific research questions addressed in the presented study. The template was based on a digital elevation model of Germany. It was combined with geological maps from Hesse (HLNUG), Lower Saxony (LBEG Niedersachsen), Bavaria (LfU Bayern), and Baden-Württemberg (LGRB-BW).

A petrographic analysis of the samples was conducted using an optical microscope (Zeiss Stemi 2000) with a magnification of 80x. Each specimen was studied under reflected light and the observations were recorded in a database. For a better understanding of the formation of the studied materials and in order to describe the properties of components (especially in case of silicified sandstone), selected samples were studied with transmitted light. For this purpose, thin sections of 30 µm were prepared at the Department of Earth Sciences of ETH Zurich and analyzed using a Nikon SMZ1500 with an integrated camera.

For the study of lithic raw materials commonly found within carbonate platforms, the microfacies analysis was applied (Flügel 1982; Flügel 2010). The term 'microfacies' refers to 'the total of all sedimentological and paleontological data which can be described and classified from thin sections, peels, polished slabs or rock samples' (Flügel 2010: 1). This method involves a detailed description of the texture and the components of a rock sample. Based on the amount of components as well as their degree of preservation, the sample is assigned to a specific environment in which the rock was formed. It is possible to distinguish between different marine and lacustrine environments, such as a tidal zone, a reef, a continental shelf, a pelagic milieu, or a freshwater lake. The occurrence of microfossils allows ascribing the samples to a specific geological time period. In the framework of the presented study, rock samples were classified according to the work of Dunham (1962). The application of microfacies analysis for the sourcing of lithic raw materials has already yielded interesting results concerning prehistoric mobility patterns and subsistence strategies in Switzerland and Southern Germany (Affolter 2002; Kaiser 2013; Hess 2019).

In case of silicified sandstone, the classification scheme that is used for the petrographic description of clastic sedimentary rocks was applied (Füchtbauer 1988; Tucker 1992). It is based on the analysis of parameters like grain size, roundness, sorting, and the homogeneity of the sample. As the mentioned aspects are supposed to be a function of the transport distances of components, they also contain information on the environment in which the rock was formed. In addition, it was possible to observe various degrees of quartz overgrowth, leading to an interlocking texture as a result of tectonic stress.

In addition to the texture of the raw materials, the properties of the cortex were considered (***Figure 2***). In this case it was possible to distinguish between a primary cortex, a rounded surface—that is typical for a transport by rivers and moraines—and a cortex that is the result of chemical weathering (Affolter 2002: 19; Kaiser 2013: 81).

Sample colour was determined using the Munsell Color Chart and the Munsell Rock Color Book.

An important advantage of studying samples with optical microscopy under reflected light is the fact that the method is non-destructive and can be performed without expensive equipment (Affolter 2002). Therefore, it is possible to analyse every single object within an archaeological assemblage and compare large numbers of sites that are part of a wider region.

RESULTS

A petrographic analysis of the collected samples allowed characterizing the different raw materials with regard to geoarchaeological research questions. Furthermore, the investigations gave interesting new insights into the formation of certain rock types. In the following paragraph, the raw materials occurring in the study area will be discussed in detail.

SILICEOUS SHALE

Siliceous shale *(Kieselschiefer)* is a fine-grained sedimentary rock that was formed in a pelagic environment below the CCD (carbonate compensation depth) (Füchtbauer 1988). Petrographically, it can be described as a dark radiolarian chert, dating to the Palaeozoic (Silurian to Carboniferous). Some specimens contain iron oxide (pyrite) (cf. Pflug 1993: 76). The material is laminated and shows a relatively low percentage of components (mudstone). Due to varying

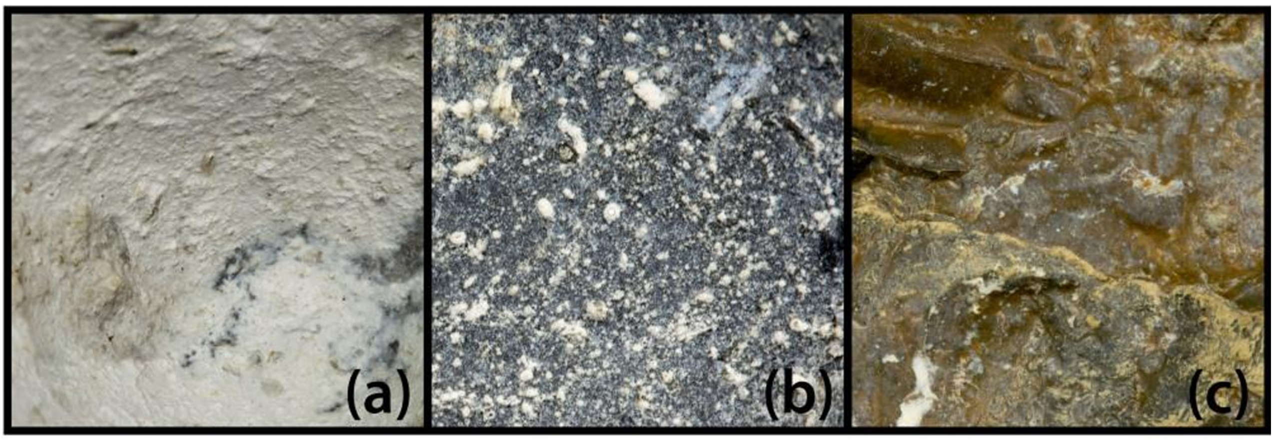

Figure 2 Different types of cortex. **(a)** Primary cortex. **(b)** Battered due to the transport by water. **(c)** Altered by chemical weathering. (Figure: T. Hess).

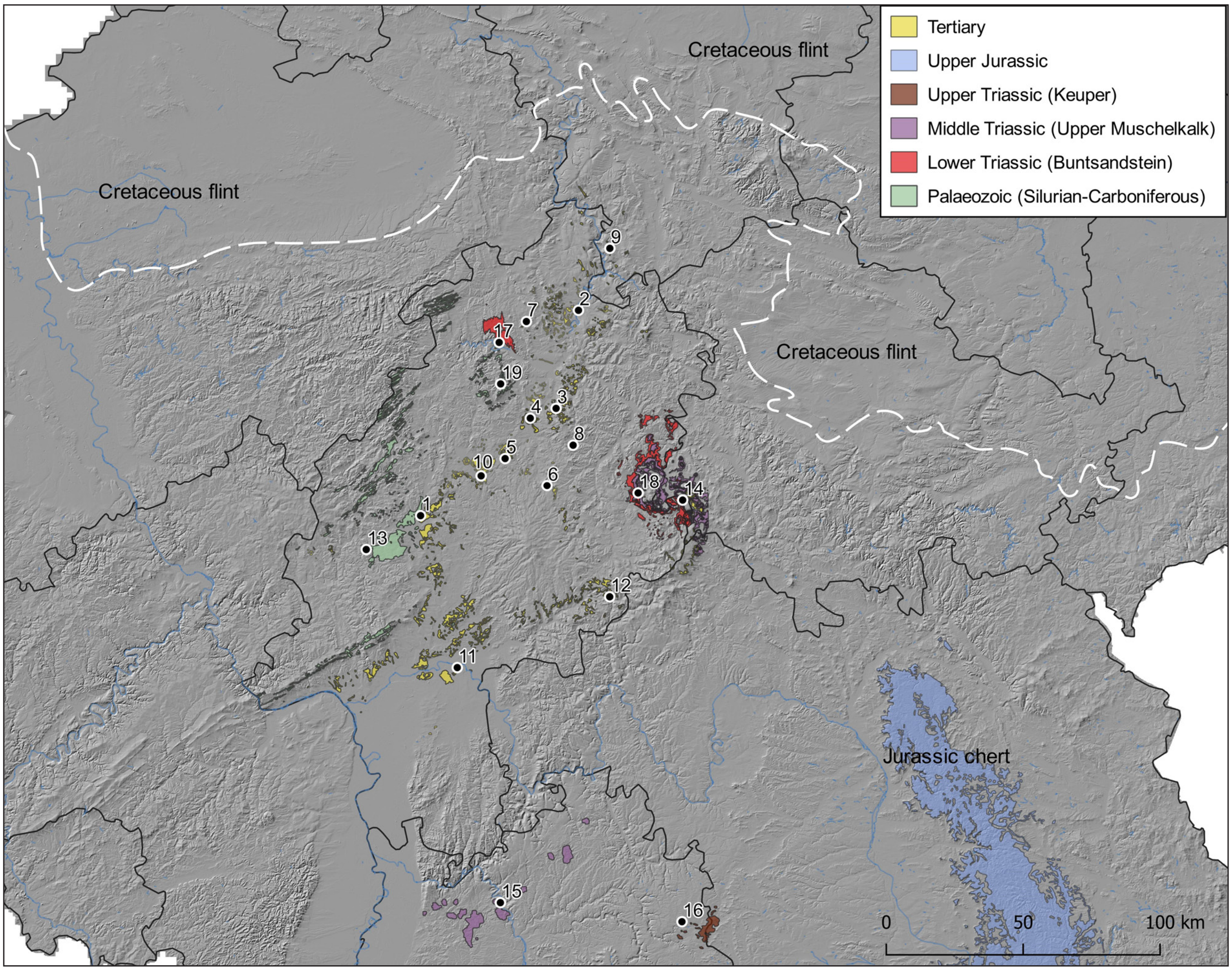

Figure 3 Occurrence of lithic raw materials in Central Germany. 1. Siliceous shale, river Lahn (HE). 2. Siliceous shale, Kassel (HE). 3. Silicified sandstone, Lenderscheid (HE). 4. Silicified sandstone, Rörshain (HE). 5. Silicified sandstone, Wahlen (HE). 6. Silicified sandstone, Rainrod (HE). 7. Silicified sandstone, Balhorn (HE). 8. Silicified sandstone, Hausen (HE). 9. Silicified sandstone, Dransfeld (NI). 10. Chalcedony, Homberg (HE). 11. Chalcedony, Lämmerspiel (HE). 12. Chalcedony, Schlüchtern (HE). 13. Chalcedony, Braunfels a. d. Lahn (HE). 14. Triassic chert (Muschelkalk), Theobaldshof (HE). 15. Triassic chert (Muschelkalk), river Neckar (BW). 16. Triassic chert (Keuper), Hohenlohe (BW). 17. Triassic chert (Buntsandstein), Buhlen (HE). 18. Triassic chert (Buntsandstein), Hünfeld (HE). 19. Jasper, Kellerwald region (HE). White line: Maximum extent of ice during the Pleistocene glaciation. Source: DGM 200, © GeoBasis-DE/BKG 2019, HLNUG, LBEG, LfU Bayern, LGRB-BW (Figure: T. Hess).

degrees of tectonic stress, there are considerable differences concerning the preservation and visibility of microfossils (***Figures 4a,b*** and ***10a***). In some cases, the skeletons of radiolarians are almost completely absent. The colour of the material derives from carbonaceous particles (Carozzi 1960). It ranges from black to dark olive green (5.0Y 2/2, 5.0Y 6/4, 5.0GY 3/4). Sometimes, the surface of green specimens is weathered and displays a rusty to brown colour. The fracture behaviour of the material, leading to characteristic angles of 120° and 60°, is a direct consequence of its lamination.

Siliceous shale is the most common locally available raw material in the western part of Central Germany. It occurs in a variety of different sizes within river gravels and terraces. Important secondary sources are the river systems of Lahn, Eder, Main, and the Central Rhine Valley (cf. Krüger & Taute 1964: 21; Pflug 1993: 76–77; Fiedler 2017: 4). Primary outcrops are situated in the Rhenish Massif and the Thuringian Highlands where the material is abundant in the form of large layers (***Figure 3***). Most of the raw stones used by prehistoric hunter-fisher-gatherers show a battered surface that is typical for a transport by rivers (***Figure 4b***) (cf. Hess & Riede 2021).

SILICIFIED SANDSTONE

In Hesse, outcrops of silicified sandstone *(Tertiärquarzit)* are present on densely wooded hilltops that form prominent spots in the landscape. As the material is extremely hard and resistant, the formations were less affected by erosion processes and the respective zones are not suitable for agriculture (Lotz, 1995: 70). Because of its high content of silica, silicified sandstone was quarried in modern times for the glass and chamotte industry. The rock formed during the Tertiary by the cementation of sand layers by silica that derived from volcanic rocks and was dissolved by groundwater (Freyberg 1926) (***Figure 3***). The colour of the material is

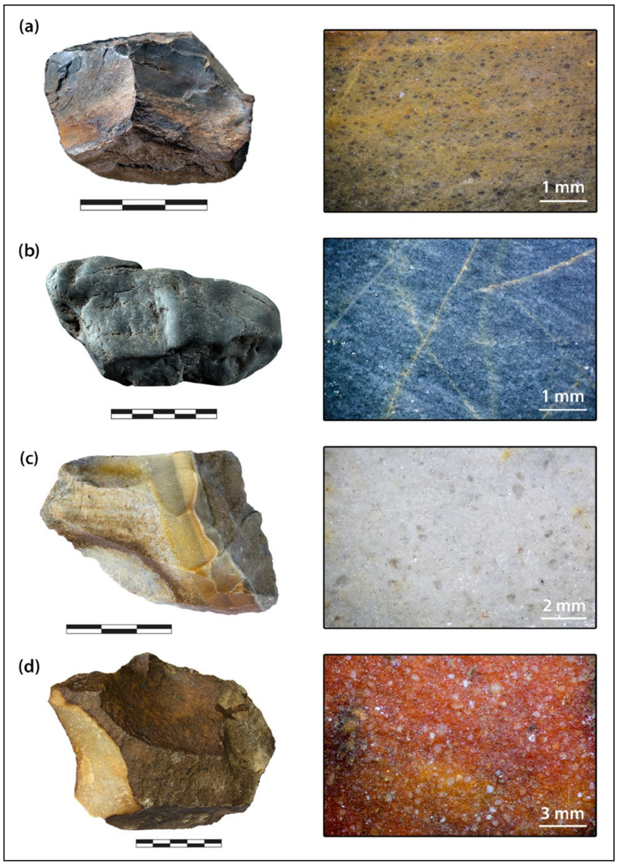

Figure 4 Raw material samples: **(a)–(b)** Siliceous shale. **(c)** Silicified sandstone, Lenderscheid. **(d)** Silicified sandstone, Rörshain. (Figure: T. Hess).

determined by the variable presence of iron oxide (red, brown) or minerals such as olivine and epidote (green). Besides large boulders with a diameter of several meters, there are small nodular pieces. Furthermore, breccious samples were documented. Interestingly, the degree of sorting of silicified sandstone found within the study area increases from northwest to southeast, following tectonic fault systems.

Lenderscheid (Schwalm-Eder-Kreis)

A particularly fine-grained variant of silicified sandstone occurs in Lenderscheid. The raw material was already used by various Middle Palaeolithic groups for the production of lithic artefacts including handaxes, points, and Levallois cores (Fiedler 1994: 64–65). Traces of mining date to the Neolithic. Silicified sandstone from Lenderscheid is very well-sorted and shows a high component/matrix ratio. The grains are relatively small in size and rounded to well-rounded. The sphericity is moderate to high. In some cases clasts are interlocked. (***Figures 4c*** and ***7a***) The most common colours are white (10.0Y 9/2), grey (5.0Y 5/2), pink (5.0R 6/12, 5.0R 7/8), and orange (5.0Y 7/20, 2.5YR 6/18).

Rörshain(Schwalm-Eder-Kreis)

Near Rörshain—situated about 12 km to the southwest of Lenderscheid—a slightly more coarse-grained type of silicified sandstone occurs. In thin section, the material is well-sorted and shows spherical, subrounded to rounded clasts. The contact between grains is tangential and there is a higher amount of matrix compared to silicified sandstone from Lenderscheid (***Figure 7b***). Frequently, iron-oxide was documented. Colours range from olive green (5.0Y 5/4), over dark orange (5.0YR 5/8) to red (10.0R 3/8) (***Figure 4d***). Additionally, a yellow variant (10.0YR 6/8) was documented (***Figure 5a***). As single grains are visible macroscopically, the surface appears particularly sparkly in bright light. In addition to the nearby Early Palaeolithic site Reutersruh (Luttropp 1949; Luttropp & Bosinski 1971), raw material from Rörshain was used at the Mesolithic open-air site Feuersteinacker near Stumpertenrod (Hess & Riede 2021).

Wahlen (Vogelsbergkreis)

Silicified sandstone documented in Wahlen in the valley of the river Antrift, shows strong similarities to the raw material from Rörshain. This is particularly true for the colour that includes yellowish green and dark orange. The material is a bit more coarse-grained and moderately well-sorted. Clasts are spherical and subrounded to rounded (***Figure 5b***). The primary cortex of the rock consists of relatively large quartz grains and has a brownish grey colour (7.5YR 5/2). Besides a Middle Palaeolithic workshop near the outcrop (Fiedler 1994: 87–88), silicified sandstone from Wahlen is present in several Mesolithic sites in Hesse.

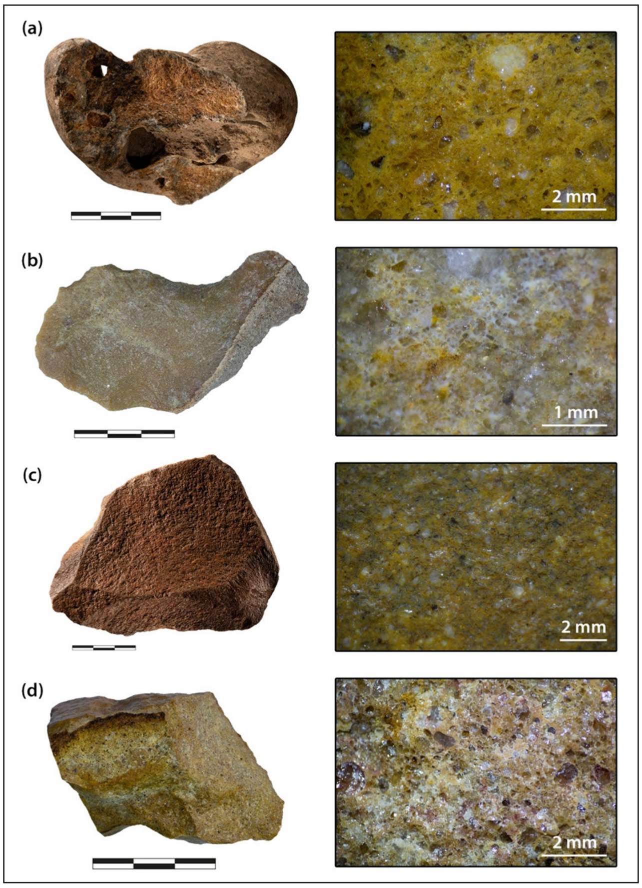

Figure 5 Raw material samples. **(a)** Silicified sandstone, Rörshain. **(b)** Silicified sandstone, Wahlen. **(c)** Silicified sandstone, Rainrod. **(d)** Silicified sandstone, Balhorn. (Figure: T. Hess).

Rainrod (Vogelsbergkreis)

Surface finds near Rainrod suggest an occupation during the Middle Palaeolithic, the Mesolithic, and the Neolithic (Fiedler 1994: 74–75). The locally available silicified sandstone is moderately well-sorted. The grains are subrounded to rounded, spherical, and the component/matrix ratio is relatively high. In some cases, the clasts are interlocked (***Figure 7c***). The colour of the material is white to pale brown (5.0Y 9/2). Weathered samples show a typical reddish brown, sparkly patina (5.0YR 5/8) (***Figure 5c***).

Balhorn (Landkreis Kassel)

A rock sample from the northern part of Hesse was collected in Balhorn around 15 km to the west of Kassel. The material is moderately sorted and single grains are visible macroscopically. Clasts are subangular to well-rounded with an overall moderate sphericity. In some cases there is long contact between single clasts that are otherwise isolated within the matrix (***Figures 5d*** and ***7d***). The colour of the material is a yellowish or reddish brown (7.5YR 6/6). Weathering processes lead to a brown dull patination.

Hausen (Schwalm-Eder-Kreis)

Another workshop that might have been occupied already during the Lower Palaeolithic (Acheulean) was discovered by Luttropp on a hilltop near Hausen (Fiedler 1994: 58). The material that was studied in thin section is well-sorted and contains subangular to well-rounded grains within a light greenish grey matrix (***Figures 6a*** and ***7e***). Additionally, remains of algae were documented. Typical colours are grey (5.0Y 8/2) and pale brown (10YR 7/4).

Dransfeld (Göttingen, Lower Saxony)

An important outcrop of silicified sandstone is located on the Dransfeld Plateau in Lower Saxony. In a small forest northwest of the village of Bühren, the material occurs in the form of large blocks of several metres in close proximity to basalt formations. It is homogenous and has a light grey (N7) to pale brown (10YR 7/4) colour. The rock is well-sorted and clasts are spherical as well as subrounded to rounded. Due to tectonic processes, the grains are more interlocked compared to other types of silicoclastic raw materials in the study area (***Figures 6b*** and ***7f***). Silicified sandstone from the Dransfeld Plateau was used by Mesolithic hunter-gatherers in Lower Saxony (Grote 1993) Pit structures that were dug in order to extract the raw material, are Neolithic in age.

CHALCEDONY

Another locally available lithic raw material is chalcedony *(Chalcedon)*. It is characterized by a greasy to vitreous lustre and a translucent surface. The colour spectrum

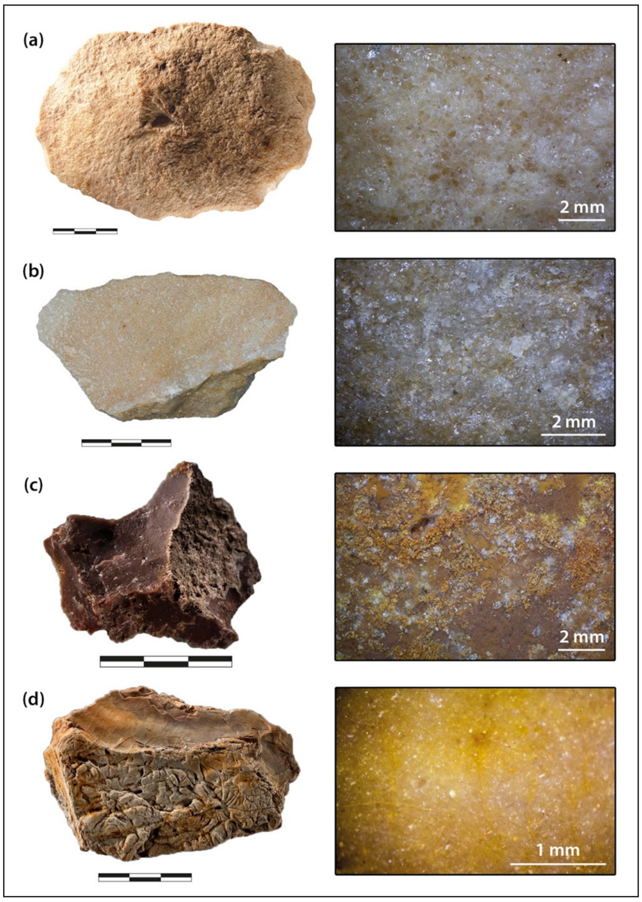

Figure 6 Raw material samples. **(a)** Silicified sandstone, Hausen. **(b)** Silicified sandstone, Dransfeld. **(c)** Chalcedony, Rörshain. **(d)** Chalcedony, Homberg a. d. Ohm. (Figure: T. Hess).

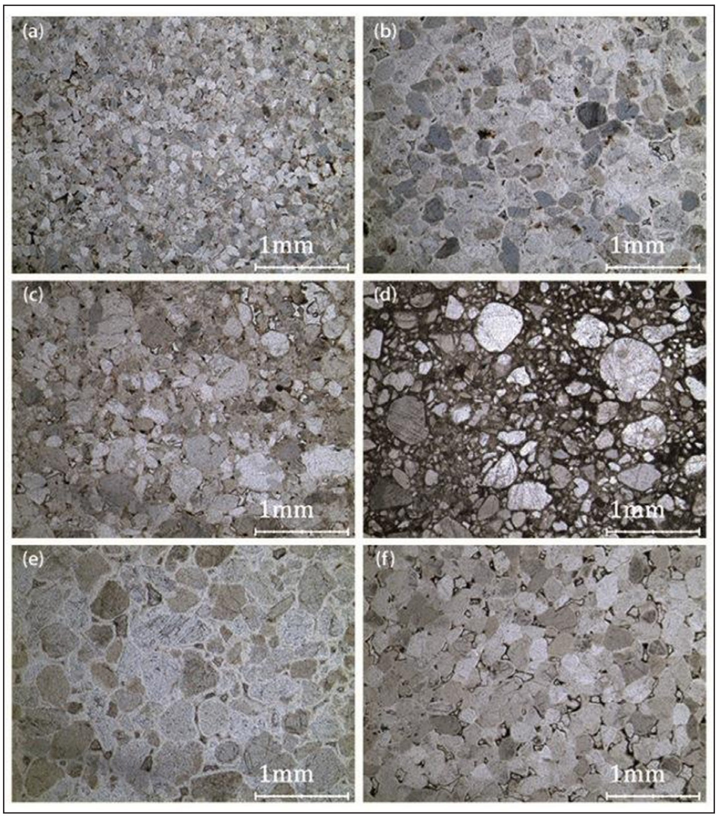

Figure 7 Thin sections of lithic raw materials. **(a)** Silicified sandstone, Lenderscheid. **(b)** Silicified sandstone, Rörshain. **(c)** Silicified sandstone, Rainrod. **(d)** Silicified sandstone, Balhorn. **(e)** Silicified sandstone, Hausen. **(f)** Silicified sandstone, Dransfeld. (Figure: T. Hess).

is extremely diverse and ranges from brown (2.5YR 2/2, 7.5YR 3/2) and grey (2.5Y 5/2) over yellow (10YR 6/14) and orange (5.0YR 7/20, 5.0YR 8/14) to red (10.0R 3/10, 10.0R 3/8), light blue (10.0BG 9/2), and green (7.5Y 5/6). Opaque yellow and black parts were documented in combination with more silicified zones. In older German publications (e.g. Deecke 1933), the former are also called *'Opal'*. The occurrence of chalcedony is strongly associated with the presence of volcanic rocks dating to the Tertiary (***Figure 3***). Primary outcrops of the material are situated in Steinheim near Frankfurt (Behn 1925; Deecke 1933: 5–6), Braunfels a. d. Lahn (Fiedler 2017) as well as Nieder-Ofleiden (Homberg a. d. Ohm). Petrographic analyses reveal the presence of microfossils that are typical for a lacustrine environment, such as gastropods—which are sometimes also part of the cortex—ostracods, and remains of green algae (Charophyta) (cf. Alonso-Zarza & Wright 2010; Flügel 2010: 448–450) (***Figure 10b–d***). Additionally, characteristic structures of silicified wood were documented (***Figures 8a*** and ***10f***). This leads to the conclusion that the mentioned variant of chalcedony was formed in a Miocene lake by the silicification of trees and algal mats. The silica derived from the chemical weathering of volcanic rocks. As the volcanic structures in Hesse are the result of multiple eruptive events, chalcedony can be found in the form of alternating layers within basalt formations. Therefore, the material is also referred to as *'Basalthornstein'*.

CRETACEOUS FLINT

Cretaceous flint is a strongly silicified raw material that is present in moraines of the Saale and Elster glaciation north of 51° latitude (Floss 1994: 103) (***Figure 3***). Generally, it is translucent and shows a vitreous lustre. Secondary deposits are situated in Lower Saxony (Grote 1993) and Thuringia (Weber 2013). The mentioned rocks can be classified as mud- and wackestones, containing remains of sponges, foraminifera, green algae, and pollen of coniferous trees. Additionally, fish vertebrae and bryozoans were documented (***Figure 8b***). Typical colours include dark brown (5.0YR 3/4), yellow (10.0YR 8/12), and white (2.5Y 8/2). Pieces that were exposed to heat display a typical white patination.

Furthermore, Cretaceous flint from alluvial terraces of the rivers Rhine and Maas/Meuse played a certain role as a lithic raw material in the western part of Central Germany (Floss 1994; Gelhausen et al. 2003; Hess & Riede, 2021: 259). Due to their characteristic egg-shaped appearance,

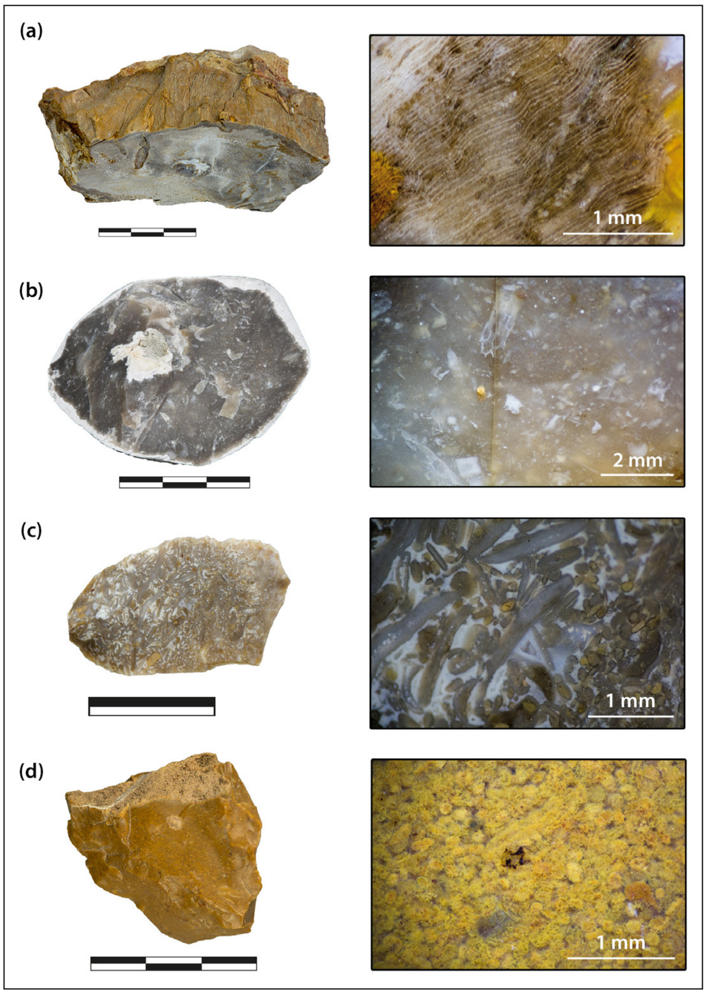

Figure 8 Raw material samples. **(a)** Silicified wood, Braunfels a. d. Lahn. **(b)** Cretaceous flint. **(c)–(d)** Triassic chert (Muschelkalk), Theobaldshof. (Figure: T. Hess).

pebbles occurring within Oligocene deposits are also called *'Maaseier'*. They often show typical concentric zoning (so-called Liesegang rings) in combination with planktonic foraminifera and triaxon sponge spicules.

TRIASSIC CHERT (MUSCHELKALK FORMATIONS)

Within the study area, siliceous concretions occur in limestones and marls on the border between the Middle and the Upper Muschelkalk within formations running from the southwest to the northeast (Pflug, 1993: 71) (***Figure 3***). An important outcrop was documented in Theobaldshof in the Rhön Mountains. Chert nodules were discovered within oolitic limestone layers belonging to the Upper Muschelkalk (Moayedpour 1977: 15–20). They are classified as packstones, originally deposited at the margins of a carbonate platform. The fossils are visible even macroscopically and include coated shells of brachiopods and bivalves in combination with oncoids and ooids (***Figure 8c***). Furthermore, there is a variant including well-sorted fine-grained ooids (grainstone) that are characteristic for an intertidal environment (***Figure 8d***). Typical colours are yellow (2.5Y 6/14) and dark grey (5Y 6/2).

Additionally, chert from Muschelkalk formations from the south of the investigated area was imported to sites in Central Germany (Hess & Riede, 2021). Primary outcrops and secondary sources are situated along the rivers Neckar and Rhine (Siegeris 2010; Spies 2017: 38–41).

TRIASSIC CHERT (KEUPER)

An important outcrop of chert from Keuper formations is located on the Hohenlohe Plateau in the north of Baden-Württemberg (***Figure 3***). In this area, nodules of the size of a fist are available in the form of secondary deposits within local fields. The material is translucent and shows grey (5.0Y 5/2), yellow to orange (10YR 6/12), and dark red (5.0YR 3/8) zoning. Frequently, the cortex displays a characteristic dark glossy patina, reminding of so-called 'desert-varnish' or 'wind-gloss' (***Figure 2c***). This is probably due to a combination of chemical and mechanical weathering processes. Microfossils including gastropods, remains of green algae, diatoms, dinoflagellate cysts, and pollen of coniferous trees suggest that the rock was formed under semiarid to arid conditions in a lacustrine environment (***Figure 9b***). Triassic chert from Hohenlohe shows numerous micro-fissures filled with secondary quartz cement. The rocks are part of the Trossingen and Stubensand formations (Middle Keuper) (Simon & Schüssler 2014: 29–38). Silica deriving from the weathering of clay minerals replaced the original sediments that had been deposited in shallow lakes. Despite the good availability of cherts from

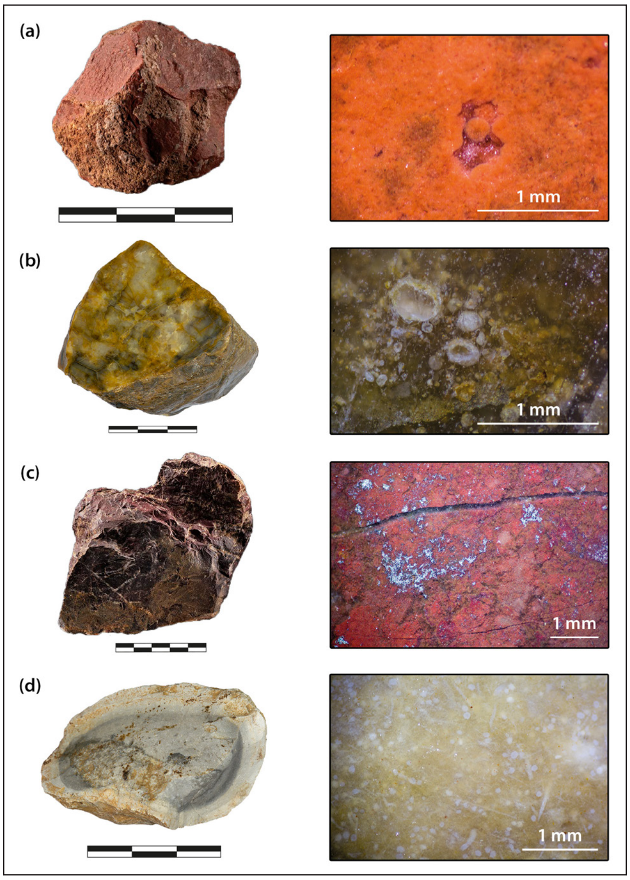

Figure 9 Raw material samples. **(a)** Triassic chert (Keuper), Hohenlohe. **(b)** Triassic chert (Buntsandstein), Buhlen. **(c)** Jasper, Kellerwald region. **(d)** Jurassic chert. (Figure: T. Hess).

Keuper formations, it seems that they were only of local importance and played a minor role as a raw material throughout prehistory.

TRIASSIC CHERT (BUNTSANDSTEIN FORMATIONS)

Within the study area, so-called carnelian *(Karneol)* occurs in Lower Triassic (Middle Buntsandstein) formations, such as the Solling-sequence in the form of relatively small nodules (<5 cm) that are embedded in dolomite layers. Important primary sources are the Odenwald region in the south of Hesse and Northern Bavaria (Backhaus, 1975), as well as the borderland between Hesse, Thuringia, and Lower Saxony (Pflug 1993: 73) (***Figure 3***). Another outcrop was documented near Buhlen in the Eder Valley. The material in the study area is usually opaque and shows a dull lustre, although it includes zones that are more silicified. A microscopic analysis reveals spherical aggregates of fibrous quartz and a low percentage of components (mudstone) (cf. Pflug 1993: 74) (***Figure 9a***). Shrinkage cracks and the occasional presence of ooids point towards a formation in an intertidal or supratidal environment as part of an evaporite rock sequence (cf. Flügel 2010: 663). The colour of the material is a consequence of iron oxides and ranges from brownish red (2.5YR 4/8) to red orange (10R 5/8, 2.5YR 5/10), and pink (7.5R 5/10). Frequently, the cortex is strongly weathered by dissolution processes.

JASPER KELLERWALD REGION

Jasper from the Kellerwald region *(Kellerwald Jaspis/Eisenkiesel)* can be found in the form of large boulders in the north of Hesse. Furthermore, it is present within gravels of the rivers Eder and Lahn (***Figure 3***). Its dark red (7.5R 3/4, 5.0R 3/6) and green (5.0Y 5/4) colour derives from iron oxide and manganese. The rock is of Palaeozoic (Devonian/Carboniferous) origin and its genesis is linked to hydrothermal vents (cf. Schneiderhöhn 1941). Petrographic analyses reveal quartz veins, inclusions of hematite, and the occasional presence of radiolarian within a matrix that contains red to orange spherical structures. Due to its high density (2.65 g/cm^3), it is relatively heavy. According to current knowledge, jasper played only a minor role for the production of prehistoric stone tools in the study area (Pflug, 1993: 80; Hess & Riede, 2021). However, there are a few cases of potential hammerstones (Kegler-Graiewski 2007: 117).

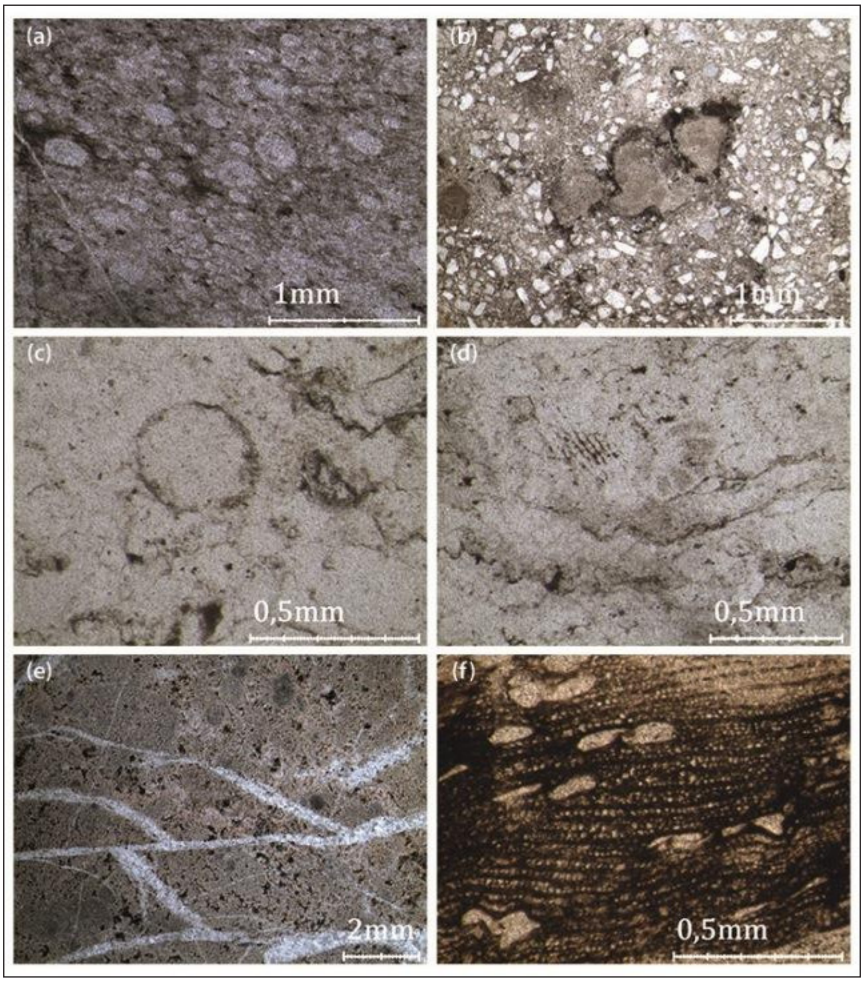

Figure 10 Thin sections of lithic raw materials. **(a)** Siliceous shale. **(b)–(d)** Chalcedony. **(e)** Jasper, Kellerwald region. **(f)** Silicified wood. (Figure: T. Hess).

JURASSIC CHERT

Jurassic chert formed within a carbonate platform of the Tethys Ocean (Geyer & Gwinner 2011). Primary outcrops are situated in limestone layers of the Swabian and the Franconian Jura (***Figure 3***). The largest part of the material in question was formed during the Upper Jurassic. Within the investigated area, the material exclusively occurs in the form of small pebbles in alluvial terraces of the river Main. The latter show a battered cortex that is the consequence of a transport by water. Petrographic aspects and the fossil content of Jurassic chert have been studied in great detail (Affolter 2002; Binsteiner 2005; Altorfer & Affolter 2011; Burkert 2013; Kaiser 2013; Hess 2019). Most of them are classified as mudstones and wackestones that point to a neritic environment. Common microfossils are sponge spicules, bivalves, gastropods, ostracods, foraminifera, corals, and bryozoans. Predominant colours are grey (10.0YR 7/2) and white (5.0Y 9/2).

DISCUSSION AND CONCLUSION

The presented results illustrate the large diversity of lithic raw materials in the study area and their availability throughout time. Rock types for crafting important items were crucial for the life of prehistoric groups in the region. Outcrops of silicified sandstone in the central part of Hesse—where the raw material is abundant in substantial quantities (***Figure 3***)—were particularly suitable for the production of large discoid cores as well as handaxes. There are several examples of surface finds dating to the Lower Palaeolithic that consist of silicified sandstone (e.g. Luttropp & Bosinski 1971). Middle Palaeolithic workshops are usually centred in direct proximity of the mentioned raw material sources and the distribution of sites in the landscape points towards small territories (Bosinski 1967). The abundance of resources allowed the production of *(ad hoc)* stone tools with a relatively short use-life compared to areas where lithic raw materials are more scarce, in addition to pieces that were resharpened. Besides objects consisting of silicified sandstone, artefacts made of siliceous shale and chalcedony are regularly documented in Middle Palaeolithic assemblages (e.g. Rörshain or 'Schusterköppel' near Hattendorf). There are considerably fewer archaeological sites dating to the Early Upper Palaeolithic in the region (Fiedler 1997: 126). Important exceptions are the cavesites Wildscheuer and Wildweiberlei, situated in the valley of the river Lahn (Terberger 1993). The lithic assemblage from the Aurignacian layers of Wildscheuer consists almost exclusively of locally available siliceous shale (98.4%) together with a few artefacts made of chalcedony (Terberger, 1993: 32). Within the Gravettian and Magdalenian layers—still dominated by siliceous shale—the amount of chalcedony is considerably higher. Magdalenian sites in Hesse, e.g. the open-air site Dreieich-Götzenhain, 16 km south of the river Main, are furthermore characterized by imported Cretaceous flint and Jurassic chert (Terberger, 1993: 120; Terberger et al. 2013) used in the framework of a blade and bladelet industry. During the Late Palaeolithic and especially during the Early Mesolithic, there was an increased use of local raw materials, such as chalcedony and silicified sandstone, which seems to be linked with shifting subsistence strategies and generally smaller territories. Apparently, salt springs were another important parameter concerning settlement patterns of prehistoric groups during the final part of the Pleistocene and the Early Holocene (cf. Hofbauer 1992). In addition to attracting potential prey, they could be linked with the conservation of meat and fish. Based on the results of lithic sourcing and the study of settlement patterns, it is possible to propose a higher degree of logistic mobility with the onset of the Holocene (cf. Binford 1980; Hess & Riede 2021). Instead of processing the raw materials near the respective outcrops, they were transported over large distances and transformed to microliths at specialized workshops (Hess in preparation). Rivers and low mountain ranges served as important landmarks and axes of orientation. Interestingly, a comparison of Mesolithic assemblages implies that there are marked differences in terms of the composition of lithic raw materials between the north and the south of the study area. While the northern part of Hesse shows strong cultural similarities to Lower Saxony (as evident in case of the sites Bodes or Hofgeismar), including a higher percentage of tools made of Cretaceous flint and siliceous shale, Mesolithic sites in the south (e.g. Feuersteinacker or Hattendorf) display parallels to adjacent regions in northeastern Bavaria and Baden-Württemberg (e.g. the presence of heat-treated Jurassic and Triassic chert). As lithic raw materials associated with Tertiary volcanics (such as silicified sandstone and chalcedony) are often weathered when exposed to the surface, it is possible to suggest a simple form of mining (e.g. small pit structures or or ditches) during the mentioned time period. A Mesolithic site near Rainrod yielded worked pebbles of the size of a football that were used to break large blocks of silicified sandstone into smaller pieces (Fiedler 1994: 74). In combination with large amounts of lithic raw material of stable quality, a technological system based on microliths allowed new ways of economic and social interactions, including the serial production of stone tools and a far-reaching contact network despite of a higher degree of territorialization. Petrographic analysis of stone tools discovered at Feuersteinacker, indicate that Mesolithic hunter-gatherers imported lithic raw materials from distances of up to 150 km (Hess & Riede 2021) Furthermore, a comparison of topographic parameters showed that the locality—nowadays situated in a rather remote area—was an important transportation hub and gatherings of otherwise dispersed groups took place at the site.

During the Neolithic, people dug open pits of several metres to reach layers of silicified sandstone that were particularly suitable for the production of laminar blanks (cf. Heidenreich, 1996). Some outcrops yielded evidence for an occupation that lasted until the Bronze Age. Of great interest in this context is the spatial connection between a quarry on the Dransfelder plateau and a site interpreted as a sanctuary, where large horizontal stones containing cupules were discovered (Golzio, 1970).

Even in historic times, the raw materials discussed here continued to play an important role for people living in the area. Chalcedony and chert from Keuper formations were sold as gemstones to manufactories at the castles of Neuenstein and Kassel (Schüssler 2014: 75–79). In addition, surface finds of Mesolithic stone artefacts served as strike-a-lights until the beginning of the 20th century (Krüger & Taute 1964: 19)—a remarkable example for the re-use of resources over a time period of thousands of years.

The presented reference collection forms the basis for further investigations, including systematic provenance analyses of additional assemblages. It is possible to complement the data by conducting surveys with a focus on lithic raw materials in adjacent regions or by combining them with the results of other studies. In addition to optical microscopy, specific raw material types, such as silicified sandstone, could be analysed with geochemical methods, e.g. XRF (cf. Blomme et al. 2012; Della Torre et al. 2020).

The data collected in the framework of this study contribute to a better understanding of mobility patterns and territories in the past and are of high value for further spatial analysis, aimed at discovering additional archaeological sites in the study area (see Sauer et al. 2018). In the sense of a theoretical approach that considers the materiality of lithic artefacts (cf. DeMarrais et al. 2004; Hess 2019), the type of raw material that was used for the production of stone tools plays an important role for an archaeological definition of the respective cultural groups.

DATA ACCESSIBILITY STATEMENT

The data that support the findings of this study are included in the article (and its supplementary materials). Further information, including access to the reference collection, is available from the corresponding author, [T. H.], upon reasonable request.

ADDITIONAL FILE

The additional file for this article can be found as follows:

- **Supplementary Materials.** Shapefiles of geological units relevant for this study. DOI: *https://doi.org/10.5334/oq.108.s1*

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

Thomas Hess conceptualized the study, collected and prepared the rock samples, conducted the petrographic analysis, and wrote the paper.

Felix Riede provided scientific advice and the general infrastructure for the project.

CRediT:
Thomas Hess: Conceptualization (lead); data curation (lead); formal analysis (lead); funding acquisition (lead); investigation (lead); methodology (lead); project administration (lead); resources (equal); visualization (lead); writing – original draft preparation (lead); writing – review & editing (equal).

Felix Riede: Conceptualization (supporting); funding acquisition (supporting); project administration (supporting); resources (equal); writing – review & editing (equal).

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REFERENCES

Abrunhosa, A, Bustillo, MÁ, Pereira, T, Márquez, B, Pérez-González, A, Arsuaga, JL and **Baquedano, E.** 2020. Petrographic and SEM-EDX characterization of Mousterian white/beige chert tools from the Navalmaíllo rock shelter (Madrid, Spain). *Geoarchaeology*, 35: 883–896. DOI: *https://doi.org/10.1002/gea.21811*

Affolter, J. 2002. *Provenance des silex préhistoriques du Jura et des régions limitrophes. Archéologie neuchâteloise*, 28(2). Neuchâtel: Service et Musée Cantonal d'Archéologie.

Altorfer, K and **Affolter, J.** 2011. *Schaffhauser Silex-Vorkommen und Nutzung.* Beiträge zur Schaffhauser Archäologie, 5. Schaffhausen: Baudepartement des Kantons Schaffhausen, Kantonsarchäologie.

Backhaus, E. 1975. Der Buntsandstein im Odenwald. In Amstutz, GC, Meisl, S and Nickel, E (eds.), *Mineralien und Gesteine im Odenwald. Beiträge zum heutigen Forschungsstand,* 299–320. Aufschluß, Sonderband 27. Heidelberg: VFMG.

Behn, F. 1925. Die paläolithische Fundstelle bei Lämmerspiel, Kreis Offenbach. *Germania*, 7(2): 59–64. *https://doi.org/10.11588/ger.1923.2*

Bertola, S. 2011. The flints of Southern Alps (Non Valley, Italy) provenance found in the mesolithic site of Ullafelsen (Sellrain, Tyrol). In Schäfer, D (ed.), *Das Mesolithikum-Projekt Ullafelsen (Teil 1),* 463–505. Innsbruck: Philipp von Zabern.

Binford, LR. 1980. Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity*, 45(1): 4–20. DOI: *https://doi.org/10.2307/279653*

Binsteiner, A. 2005. Die Lagerstätten und der Abbau bayerischer Jurahornsteine sowie deren Distribution im Neolithikum Mittel- und Osteuropas. *Jahrbuch des Römisch-Germanischen Zentralmuseums*, 52(1): 43–155. *https://doi.org/10.11588/jrgzm.2005.1.18860*

Biró, KT. 2008. Comparative Raw Material Collections in Support of Petroarchaeological Studies: An Overview. In: Biró, KT and Markó, A (eds.), *Papers in honour of Viola T. Dobosi*, 225–243. Budapest: Hungarian National Museum.

Blomme, A, Degryse, P, Van Peer, P and **Elsen, J.** 2012. The characterization of sedimentary quartzite artefacts from Mesolithic sites, Belgium. *Geologica Belgica*, 15(3): 193–199.

Bosinski, G. 1967. *Die mittelpaläolithischen Funde im westlichen Mitteleuropa*. Köln: Böhlau.

Brandl, M. 2016. The multi layered chert sourcing approach (mla) analytical provenance studies of silicite raw materials. *Archeometriai Muhely*, 13(3): 145–156.

Burkert, W. 2013. Silexrohmaterial in Baden-Württemberg. In Floss, H. (ed.), *Steinartefakte – vom Altpaläolithikum bis in die Neuzeit*, 63–78. 2nd edition. Tübingen: Kerns Verlag.

Butzer, KW. 1982. *Archaeology as Human Ecology: Method and theory for a contextual approach.* Cambridge/New York, NY/Melbourne/Madrid/Cape Town/Singapore/São Paulo: Cambridge University Press.

Carozzi, A. 1960. *Microscopic Sedimentary Petrology.* New York, NY/London: John Wiley.

Deecke, W. 1933. *Die mitteleuropäischen Silices nach Vorkommen, Eigenschaften und Verwendung in der Prähistorie.* Jena: G. Fischer.

Delvigne, V, Fernandes, P, Piboule, M, Lafarge, A and **Raynal, J.-P.** 2017. Circulation de géomatières sur de longues distances au Paléolithique supérieur: le cas des silex du Turonien du Sud du Bassin parisien. Long-distance circulation of raw materials during Upper Palaeolithic times: The case of Turonian flint from the South of the Paris Basin. *Comptes Rendus Palevol,* 16(1): 82–102. DOI: *https://doi.org/10.1016/j.crpv.2016.04.005*

DeMarrais, E, Gosden, C and **Renfrew, C.** 2004. *Rethinking Materiality.* Cambridge: McDonald Institute for Archaeological Research.

Driscoll, K, Burke, AL and **Warren, GM.** 2016. Introducing LIR (Lithotheque Ireland), a reference collection of flaked stone tool raw materials from Ireland. *Journal of Lithic Studies,* 3(2): 231–251. DOI: *https://doi.org/10.2218/jls.v3i2.1444*

Elburg, R and **van der Kroft, P.** 2008. *May 2008. Flintsource.net.* Available at *http://www.flintsource.net* [last accessed 23 August 2021].

Fiedler, L. 1994. *Alt- und mittelsteinzeitliche Funde in Hessen.* Führer zur Hessischen Vor- und Frühgeschichte, 2. Stuttgart: Konrad Theiss Verlag.

Fiedler, L. 1997. *Jäger und Sammler der Frühzeit. Alt- und Mittelsteinzeit in Nordhessen.* Vor- und Frühgeschichte im Hessischen Landesmuseum in Kassel. Kassel: Staatliche Museen Kassel.

Fiedler, L. 2010. Spätmittelpaläolithische und frühjungpaläolithische Fundkomplexe in Hessen mit Blattspitzen. *Fundberichte aus Hessen*, 46/47 (2006/2007): 1–58.

Fiedler, L. 2017. *Stumpertenrod, Sammlung Horst Quehl aus den Jahren 1960–2000 (Ein Überblick über die bisher nicht publizierten Funde)*. Available at *http://altsteinzeit-hessen.de* [last accessed 23 August 2021].

Floss, H. 1994. *Rohmaterialversorgung im Paläolithikum des Mittelrheingebiets.* Monographien des RGZM 21. Bonn: Habelt.

Flügel, E. 1982. *Microfacies analyis of limestones.* Berlin: Springer. DOI: *https://doi.org/10.1007/978-3-642-68423-4*

Flügel, E. 2010. *Microfacies of Carbonate Rocks. Analysis, Interpretation and Application.* Second edition with a contribution of Axel Munnecke. Berlin: Springer-Verlag.

Freyberg, Bv. 1926. *Die Tertiärquarzite Mitteldeutschlands und ihre Bedeutung für die feuerfeste Industrie*. Stuttgart: F. Enke Verlag.

Fruth, H-J. 1994. Der spätpaläolithische Fundplatz Mühlheim-Dietesheim, Kreis Offenbach. *Fundberichte aus Hessen*, 22/23: 1–68.

Füchtbauer, H. 1988. *Sedimente und Sedimentgesteine*. 4th edition. Stuttgart: Schweizerbart.

Gehlen, B, Zickel, M, Affolter, J, Vogl, K and **Willmes, C.** 2021. Potential raw material sources for the production of lithic artefacts in western Central Europe – GIS-data for the Rhineland, Westphalia, and the Benelux countries. *Quaternary International*, 2021. DOI: *https://doi.org/10.1016/j.quaint.2021.07.015*

Gelhausen, F, Giels, L and **Aue, S.** 2003. Eine rohmaterialspezifische Kernabbautechnik im Mesolithikum – Der Oberflächenfundplatz Hülchrath, Kreis Neuss, Niederrhein. *Archäologische Informationen*, 26(1): 167–176. *https://doi.org/10.11588/ai.2003.1.12604*

Geyer, OF and **Gwinner, MP.** 2011. *Geologie von Baden-Württemberg*. 5th edition. Stuttgart: Schweizerbart.

Golzio, K. 1970. Neue Funde von der paläolithischen Schlagstelle an den Altarsteinen bei Dransfeld. *Göttinger Jahrbuch*, 18: 7–22.

Grote, K. 1993. *Die Abris im südlichen Leinebergland bei Göttingen. Archäologische Befunde zum Leben unter Felsschutzdächern in urgeschichtlicher Zeit.* Veröffentlichungen der urgeschichtlichen Sammlungen des Landesmuseums zu Hannover, 43. Oldenburg: Isensee.

Heidenreich, H. 1996. *Die Quarzitschlagplätze bei Lenderscheid, Gemeinde Frielendorf, Schwalm-Eder Kreis. Rohstoffzentrum eines Siedlungsraumes vom Paläolithikum bis zum Neolithikum.* Kleine Schriften aus dem Vorgeschichtlichen Seminar der Philipps-Universität Marburg, 45. Marburg: Universität Marburg.

Hess, T. 2019. *Das Helga-Abri im Achtal – Lithische Technologie und Rohmaterialversorgung der spätmagdalénienzeitlichen und frühmesolithischen Gruppen.* Tübingen: Kerns Verlag.

Hess, T. in preparation. Wolfgang Taute's excavation at the open-air site ‹Feuersteinacker› (1964–1966) and the Early Mesolithic in the western part of Central Germany.

Hess, T and **Riede, F.** 2021. The use of lithic raw materials at the Early Mesolithic open-air site Feuersteinacker (Vogelsbergkreis, Germany). *Geoarchaeology*, 36(2): 252–265. DOI: *https://doi.org/10.1002/gea.21828*

Hofbauer, H. 1992. Ein spätpaläolithischer Fundplatz bei Rothenkirchen, Kreis Fulda (Hessen). *Archäologisches Korrespondenzblatt*, 22: 329–340.

Högberg, A and **Olausson, D.** 2007. *Scandinavian flint – An Archaeological Perspective.* Aarhus: Aarhus Universitetsforlag.

Kaiser, MJ. 2013. *Werkzeug-Feuerzeug-Edelstein. Die Silices des südöstlichen Oberrheingebiets und ihre Nutzung von den Anfängen bis zur Gegenwart.* Stuttgart: Konrad Theiss Verlag.

Kegler-Graiewski, N. 2007. Beile-Äxte-Mahlsteine. Zur Rohmaterialversorgung im Jung- und Spätneolithikum Nordhessens. Cologne: PhD-thesis University of Cologne.

Krüger, H and **Taute, W.** 1964. Eine mesolithische Schlagstätte auf dem „Feuersteinacker" bei Stumpertenrod im oberhessischen Kreis Alsfeld. *Fundberichte aus Hessen*, 4: 18–33.

Loew, S. 2005. Der Federmesser-Fundplatz Rüsselsheim 122 am Unteren Main. *Archäologisches Korrespondenzblatt*, 35(2): 143–158.

Lotz, K. 1995. *Einführung in die Geologie des Landes Hessen.* Marburg: Hitzeroth.

Luttropp, A. 1949. Paläolithische Funde in der Gegend von Ziegenhain. In Müller-Karpe, H (ed.), *Hessische Funde von der Altsteinzeit bis zum frühen Mittelalter*, 5–18. Schriften zur Urgeschichte, 2. Marburg: Elwert-Gräfe und Unzer.

Luttropp, A and **Bosinski, G.** 1971. *Der altsteinzeitliche Fundplatz Reutersruh bei Ziegenhain in Hessen.* Fundamenta A, 6. Köln: Böhlau.

Mania, D and **Weber, T.** 1986. *Bilzingsleben III: Homo erectus, seine Kultur und seine Umwelt.* Berlin: VEB Deutscher Verlag der Wissenschaften.

Moayedpour, E. 1977. *Geologie und Paläontologie des tertiären «Braunkohlenlagers» von Theobaldshof/Rhön (Miozän, Hessen).* Geologische Abhandlungen Hessen. Wiesbaden: Hessisches Landesamt für Bodenforschung.

Moreau, L, Brandl, M, Filzmoser, P, Hauzenberger, C, Goemaere, E, Jadin, I, Helene, C, Hauzeur, A and **Schmitz, R.** 2016. Geochemical Sourcing of Flint Artifacts from Western Belgium and the German Rhineland: Testing Hypotheses on Gravettian Period Mobility and Raw Material Economy. *Geoarchaeology*, 31: 229–243. DOI: *https://doi.org/10.1002/gea.21564*

Pereira, T, Farias, A and **Paixão, E.** 2016. Presenting LusoLit: A lithotheque of knappable raw materials from central and southern Portugal. *Journal of Lithic Studies*, 3(2): 743–757. DOI: *https://doi.org/10.2218/jls.v3i2.1455*

Pflug, B. 1993. *Die Verbreitung kieseliger Gesteine in der hessischen Rhön und ihre Verwendung im Paläo- bis Neolithikum.* Materialien zur Vor- und Frühgeschichte von Hessen, 15. Wiesbaden: Landesamtes für Denkmalpflege Hessen.

Přichystal, A. 1997. Sources of siliceous raw materials in the Czech Republic. In Schild, R and Sulgostowska, Z (eds.), *Man and flint: proceedings of the VIIth International flint symposium*, 351–355. Institute of Archaeology and Ethnology, Warszawa-Ostrowiec Swietokrzyski, September 1995.

Reischmann, T and **Schraft, A.** 2009. *Der Vogelsberg: Geotope im grössten Vulkangebiet Mitteleuropas*. Wiesbaden: Hessisches Landesamt für Umwelt und Geologie.

Richter, H. 1925. Die altsteinzeitliche Höhlensiedelunge von Treis a. d. Lumda. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft*, 40(1).

Rösing, F. 1976. *Geologische Übersichtskarte von Hessen 1:300 000.* Wiesbaden: Hessisches Landesvermessungsamt.

Sánchez de la Torre, M, Rey, M, Rodríguez, N, Casado, A, Medina, B and **Llach, J.** 2014. The LithicUB project: A virtual lithotheque of siliceous rocks at the University of Barcelona. *Journal of Lithic Studies*, 1(1): 281–292. DOI: *https://doi.org/10.2218/jls.v1i1.756*

Sánchez de la Torre, M, Utrilla, P, Domingo, R, Jiménez, L, Le Bourdonnec, F-X and **Gratuze, B.** 2020. Lithic raw material procurement at the Chaves cave (Huesca, Spain): A geochemical approach to defining Palaeolithic human mobility. *Geoarchaeology,* 35: 856–870. DOI: *https://doi.org/10.1002/gea.21808*

Sauer, F. 2016. Raw material procurement economy and mobility in Late Palaeolithic Northern Bavaria. *Quartär*, 63: 125–135.

Sauer, F, Stott, D and **Riede, F.** 2018. Search for new final Palaeolithic rock shelter sites in the Federal State of Hesse. *Journal of Archaeological Science: Reports*, 22: 168–178. DOI: *https://doi.org/10.1016/j.jasrep.2018.09.021*

Schneiderhöhn, H. 1941. *Lehrbuch der Erzlagerstättenkunde. Erster Band: Die Lagerstätten der magmatischen Abfolge*. Jena: Gustav Fischer. DOI: *https://doi.org/10.1080/11035894109447135*

Schüssler, H. 2014. Hohenloher Feuersteine als Werkstoff im Kunsthandwerk. In Schüssler, H, Simon, T and Warth, M (eds.), *Entstehung, Schönheit und Rätsel der Hohenloher Feuersteine,* 75–79. 3rd edition. Bergatreute: Eppe GmbH.

Siegeris, M. 2010. *Muschelkalkhornstein in Südwestdeutschland – Geologie, Petrographie und prähistorische Nutzung*. Tübingen: Master's thesis University of Tübingen.

Sieveking, G de G and **Hart, MB.** 1986. *The scientific study of flint and chert. Proceedings of the fourth international flint symposium held at Brighton Polytechnic 10–15 April 1983*. London/New York, NY/New Rochelle, NY/ Melbourne/Sydney: Cambridge University Press.

Simon, T and **Schüssler, H.** 2014. Die Entstehung der Feuersteine. In Schüssler, H, Simon, T and Warth, M. (eds.), *Entstehung, Schönheit und Rätsel der Hohenloher Feuersteine,* 25–40. 3rd edition. Bergatreute: Eppe GmbH.

Spies, B. 2017. Die «Tiefenthaler Höhe» und das Mesolithikum in Unterfranken. *Beiträge zur Archäologie in Ober- und Unterfranken*, 10: 17–136.

Taute, W. 1971. *Untersuchungen zum Mesolithikum und zum Spätpaläolithikum im südlichen Mitteleuropa. Band 1: Chronologie Süddeutschlands*. Tübingen: Habilitation treatise University of Tübingen.

Terberger, K. 1993. *Das Lahntal-Paläolithikum*. Materialien zur Vor- und Frühgeschichte von Hessen, 11. Wiesbaden: Landesamts für Denkmalpflege Hessen.

Terberger, T, Floss, H, Heinzelmann, Ph, Kotula, A and **Serangeli, J.** 2013. Down the Rhine River ca. 16,000 years ago: new evidence from the site Dreieich-Götzenhain, Hesse. In Pastoors, A and Auffermann, B (eds.), *Pleistocene foragers: Their culture and environment. Festschrift in honour of Gerd-Christian Weniger for his sixties birthday,* 101–115. Wissenschaftliche Schriften des Neanderthal Museums, 6. Mettmann: Neanderthal Museum.

Thews, J-D. 1996. *Erläuterungen zur Geologischen Übersichtskarte von Hessen 1:300 000 (GÜK300 Hessen). Teil I: Kristallin, Ordoviz, Silur, Devon, Karbon*. Geologische Abhandlungen von Hessen, 96. Wiesbaden: Hessisches Landesamt für Umwelt und Geologie.

Tucker, M. 1992. *Sedimentary petrology: an introduction to the origin of sedimentary rocks*. Blackwell Scientific Publications.

Tykot, R. 1996. Obsidian Procurement and Distribution in the Central and Western Mediterranean. *Journal of Mediterranean Archaeology*, 9(1): 39–82. DOI: *https://doi.org/10.1558/jmea.v9i1.39*

Weber, T. 2013. Artefakt-Rohstoffe in Ostdeutschland. In Floss, H (ed.), *Steinartefakte – vom Altpaläolithikum bis in die Neuzeit*, 45–54. 2nd edition. Tübingen: Kerns Verlag.

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