

# CLASSIFICATION OF ROCKS WITHIN THE CHERT GROUP: AUSTRIAN PRACTICE

## KOVAKŐZETEK OSZTÁLYOZÁSA: AZ OSZTRÁK GYAKORLAT

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### **Abstract**

*The detection of raw materials used in the production of flaked stone tools has served as a necessary methodological component within the field of archaeology. Nevertheless, controversial debates concerning accurate terminology for SiO<sub>2</sub> varieties have inspired a terminological lacuna between the fields of geology, mineralogy and archaeology. This is due to the fact that SiO<sub>2</sub> rocks never formed the main focus of Earth Sciences, resulting in an inconsistent terminology and at times lacking a proper definition. As a result of years of research, a classification system for rocks from the chert group has been developed at the Austrian Academy of Sciences. This paper intends to give a practical approach to this classification system based on petrological, mineralogical and archaeological demands.*

### **Kivonat**

*A pattintott kőeszközök nyersanyagának azonosítása fontos része az őskori régészetnek. Mindazonáltal, a terminológiai gyakorlat ellentmondásos a kovakőzetek tekintetében, figyelembe véve a geológiai, ásványtani és régészeti megközelítést. Ennek részben oka az is, hogy a kovakőzetek a földtudományokban nem kerültek a figyelem középpontjába, ezért a terminológia következetlen és a megfelelő definíciók sem alakultak ki. Több éves kutatás eredményeképpen az Osztrák Tudományos Akadémia munkacsoportja kialakított egy osztályozási rendszert az érintett kőzetekre. A tanulmány célja, hogy bemutassa ezt a gyakorlatot amely törekszik arra, hogy megfeleljen a kőzettani, ásványtani és régészeti szükségleteknek.*

KEYWORDS: RAW MATERIAL DETERMINATION, CHERT GROUP, RADIOLARITE, FLINT, TERMINOLOGY

KULCSSZAVAK: NYERSANYAG MEGHATÁROZÁS, KOVAKŐZETEK, RADIOLARIT, TÚZKŐ, TERMINOLÓGIA

### **Introduction**

The detection of raw materials in archaeological contexts is one of the most challenging undertakings in interdisciplinary studies. This is especially true for SiO<sub>2</sub> rocks belonging to the chert group.

### **What is chert?**

*Chert is a micro- or cryptocrystalline sedimentary rock composed of silicon dioxide (SiO<sub>2</sub>). It occurs as nodules, concretionary masses and as layered deposits. Chert breaks with a conchoidal fracture, producing sharp edges. In geological terms flint and chert are the same, with the term “flint” referring to chert found in chalk. Cherts are formed in limestone.*

Both archaeologists and mineralogists are concerned with the determination and with provenance studies of rocks used for stone tool production in prehistoric times. Different approaches to such a complex issue must necessarily lead to misunderstandings.

Before physical science can be applied to clarify systems of lithic raw material procurement of

prehistoric groups, the most important step is the correct classification of the rock materials. Intense discussions with colleagues from Central and Eastern Europe showed high accordances as well as divergences defining SiO<sub>2</sub> rock materials. A commonly accepted working basis implicates a generally applicable terminology in terms of determining these lithic resources.

### **Basic overview**

Basically, rocks used for knapping activities in terms of producing stone tools are confined to SiO<sub>2</sub> – varieties. A general overview of the lithic materials in the study area used for this purpose is given in the **Appendix (Table 1)**. Members of the chert – group are highlighted.

According to these primary definitions narrowing down the field of research, the rocks belonging to the chert – group will be discussed in detail. A definition of terms used in the system and a characterisation of these rock varieties leads to the final step, a formalized determination system.

The basic framework has been developed at the Austrian Academy of Sciences in the course of determining the lithic assemblage from Krems-

Hundssteig and Krems-Wachtberg (Brandl and Reiter 2008). The high variability of raw materials found in the Upper Palaeolithic sites initiated this approach, extended experience in raw material detection in different projects all over Europe completed the coherent classification system (Antl - Weiser 2008; Binsteiner, Ruprechtsberger, Brandl et al 2006; Brandl 2009a; Brandl 2009b; Brandl 2010a; Brandl 2010b; Einwögerer in press; Neugebauer – Maresch 2008; Nigst et al. 2008; Ziehaus 2007).

### ***Definition of terms used in the Classification System (categories)***

#### **General terms**

##### **Fissures**

Fissures are naturally occurring clefts caused by tectonic activity. They are often filled either with quartz or foreign minerals like calcite (which leads to the well known “vein-structure”). Mainly they are characteristic for alpine cherts, which were highly stressed imbedded in the carbonatic host rocks.

##### **Fracture Properties**

The way different raw materials break naturally is not necessarily equatable with their knapping properties. This term is more speaking of breaking schemes in general than only of those deriving from intentional knapping actions, although in many cases they definitely coincide. The knapping properties are always contingent to the general fracture properties, but not the other way round.

Speaking of the chert group, the following fracture features can be noticed:

- Conchoidal - smooth.
- Amorphous - rough.

##### **Granularity**

The grain size is generally defined by DIN<sup>1</sup> (EN ISO) – standards. In this system they vary between very rough and coarse grained to very fine grained. A closer definition is not useful for a general classification, within certain varieties a higher resolution has to be applied.

##### **Carbonate content**

Rocks with silicified matrix originating from limestone or chalk, generally can contain a certain amount of carbonate. This carbonate reacts with hydrochloric acid (HCl) foaming up due to escaping CO<sub>2</sub>. The degree of the frothing depends on the amount of carbonate present in the actual sample. Often, the carbonate content is only

detectable in the cortex region and sometimes it is only preserved there.

##### **Matrix**

The term “matrix“ defines the general rock constituents of lithic raw materials. This is the basic composition of a rock.

Orthosilicic acid forms the cementing material of silicified rocks emerging from carbonatic bedrocks. A certain granularity is discernable in the matrix of most of those rocks, especially in alpine chert occurrences or in siliceous limestone. In many cases the material is very fine grained and granularity is not perceptible at all (like in Baltic flint). This fact mostly coincides with a high homogeneity of these raw materials.

#### **Inclusions**

##### **Fossil inclusions**

Fossil inclusions only occur in rocks, they are never contained in minerals. Micropalaontology is an especially important tool for the determination of sedimentary rocks. In alpine limestone nappes (“kalkalpin”) the following fauna remains can be distinguished:

##### **Radiolaria**

Marine protozoans of the order Radiolaria, having rigid siliceous skeletons and spicules. Radiolarians occur almost exclusively in the open ocean as part of the plankton community. Their skeletons occur abundantly in oceanic sediments.

##### **Sponge remains**

Most of the sponge remains found in cherts are members of the class *Demospongiae* (phylum *Porifera*). Their skeletons consist of the fibers of the protein spongin and spicula (“skeletal needles”). Some sponges either consist completely of spongin or of spicula. The spongin basically binds the spicula; if there are no spicula present, the skeleton is kept together with very dense fibres of spongin. In cherts, parts of sponges in every stage of preservation can be included, even entire “body parts” are preserved in rare cases.

##### **Spicula**

Spicula are pointed structures serving as a skeletal element in various marine and freshwater invertebrates. Mostly they are the skeletal needles originating from marine sponges (*Demospongiae*), consisting of silica.

##### **Crinoidea**

Crinoids, also known as “sea lilies” or “feather-stars”, are marine animals that form the class *Crinoidea* of the *echinoderms*. They can either live in shallow water or in deep sea regions. Crinoids are characterized by a mouth on the top surface that is surrounded by several feeding arms. Usually they

<sup>1</sup> Former DIN 4022, since 2007 EN ISO 14688 (classification for soils) respectively EN ISO 14689 -1 (classification for bedrock).

have a stem attached to a substrate. In most cases only the wheel - like joints of the stem of the fossil crinoidea, the so called “trochites”, are preserved in cherts, forming rectangular shaped inclusions.

### **Foraminifera**

Foraminifera (“hole bearers”) or Forams are marine microorganisms forming a large group of amoeboid protists with reticulating pseudopods. They typically produce a test, or shell, which can have either one or multiple chambers, some becoming quite elaborate in structure. These shells are made of calcium carbonate ( $\text{CaCO}_3$ ) or agglutinated sediment particles. Most commonly Foraminifera are found in Cretaceous sediments containing siliceous rocks.

Additional to those, other characteristic fossil inclusions can be distinguished in varieties of the chert group. Bryozoa, diatoms, stings from sea urchins, skeletal remains from various marine creatures, seashells of all different kinds, algae and detritus are common inclusions in cherts and complete the spectrum of possible fossil remains.

### **Non-fossil inclusions**

The commonest non-fossil inclusions in alpine  $\text{SiO}_2$  – rocks are heavy minerals like garnet, tourmaline, rutile, ilmenite, cassiterite, etc. Some chert varieties contain certain amounts of mica. Quartz geodes and  $\text{SiO}_2$  precipitations are common non-fossil inclusions as well, the precipitations can show a high variation in colour. In most cases a closer determination of foreign minerals contained in siliceous rocks can only be done accurately by applying geochemical analysis.

### ***Definition of raw materials of the chert group***

#### **Chert:**

In the broad sense, all sedimentary, organically formed  $\text{SiO}_2$  – rocks can be defined as “chert”. For a closer definition, the members of the chert – group are grouped as chert and flint, regarding their geological genesis. Chert in the classical terminology systems refers to  $\text{SiO}_2$  - rocks formed in Jurassic sediments, whereas flint originates from Cretaceous formations.

Generally, the matrix of chert is silicified and mostly contains fossil inclusions. In that sense, chert is closer defined as “Jurassic chert”. Taking into account that other  $\text{SiO}_2$  rocks of Cretaceous age exist besides the “sensu stricto flint”, the term “Cretaceous chert” is a compromise for these raw materials.

Fossil inclusions are basically used to define chert closer. Predominating microfossils are used to create subvarieties in the chert – group, such as radiolarite, spiculite or spongiolite (spongiolite).

Characterising these varieties, researchers concerned with raw material description are facing a terminology problem. Usually these subvarieties are defined depending on the percentage of microfossils included in the material. Scientists with different research background apply these characterisations to cherts at 30%, 50% or not until 70% fossils of one kind visible under the microscope (**Fig. 1**). That causes misunderstandings in international discussions and falsifies interpretation models of archaeological complexes.

A solution of this problem might be a definition after the index fossil, which defines a rock of the chert – group as a radiolarite, a spiculite or a spongiolite regardless of rating percentages. An accurate a priori valuating of international standard is barely achievable and highly prone to errors.

### **Flint**

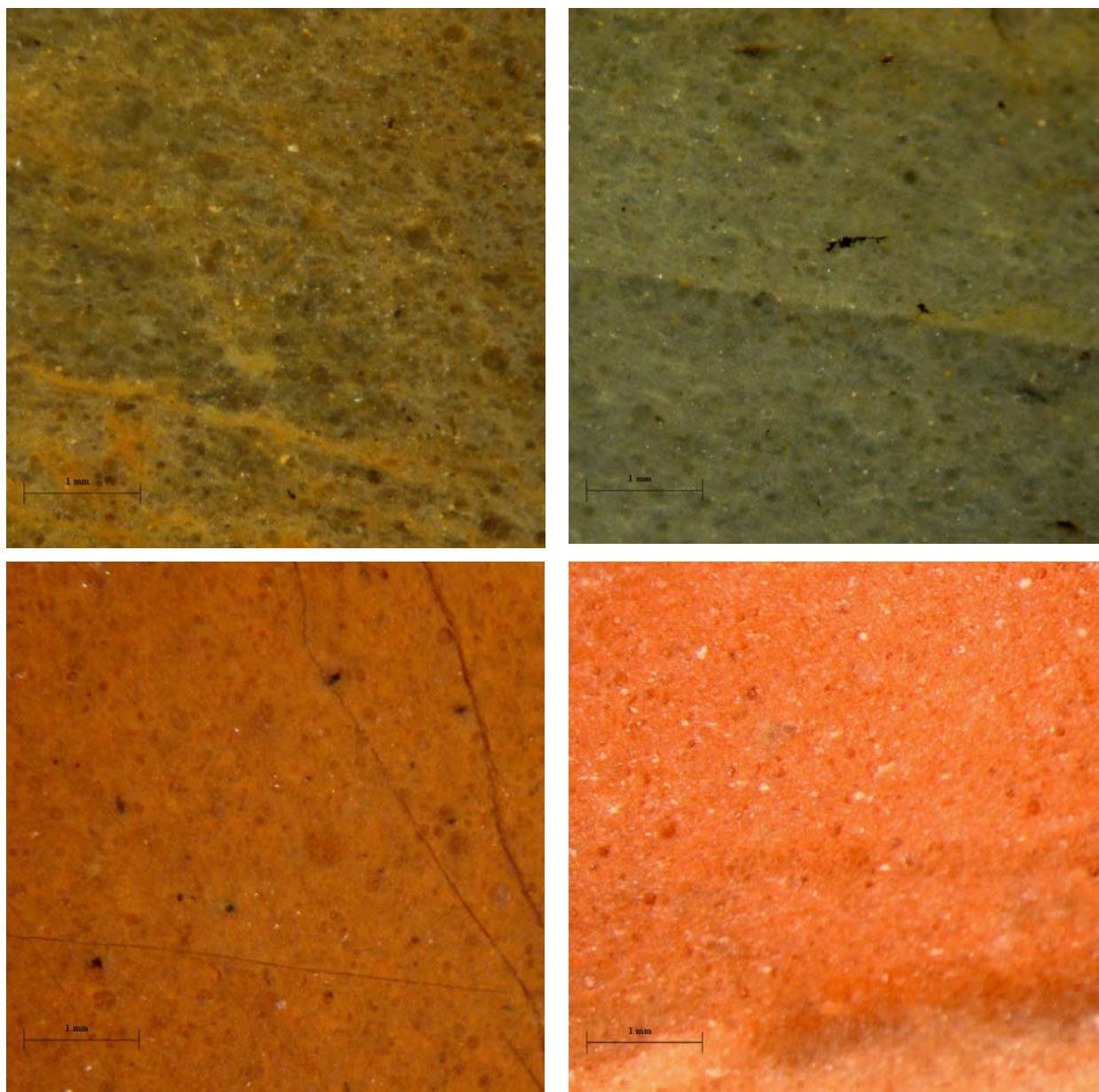
Basically, every silicified rock concretion of Cretaceous age can be defined as flint. In the narrow sense flint refers to Baltic, respectively Northern European deposits in chalk – context only. The surface of flint when fractured is very smooth and satiny and has in most cases no recognisable granularity. The material can contain a high amount of fossil inclusions, some of them can be of excellent preservation and therefore very helpful in terms of determination. Due to the genesis in chalky environments, alpine fissures are rare, which makes the material preferable for stone tool production. The “patination”, caused by surface changing processes, creates a whitish – blue coloration.

### **Siliceous limestone**

This rock material is very similar to chert and occurs in the same geological contexts. Siliceous limestone can contain high amounts of all fossil inclusions the host rock is bearing. In order to discriminate chert from siliceous limestone, some test methods have to be applied. In some cases the high similarity forces to combine several methods. In many cases, the scratch test using a steel needle shows the difference in the scratch pattern. Best results can be achieved applying the carbonate test using HCl; siliceous limestone holds carbonate remains in all cases. Calcite surfaces in the rock matrix flashing up under a reflected light microscope are further indicators.

### **Lydite (“Flinty slate”)**

Lydite is a slight metamorphic, mostly thin layered siliceous rock with a dense, slated structure. In most cases the colour is black due to organic substances. The metamorphosis usually causes the destruction of the fossil remains in the rock material, so that fossil inclusions are barely visible under the microscope.



**Fig. 1:** Micropictures of alpine “radiolarites” 1. Feuersteinmähder, Vorarlberg; 2. Rothornjoch, Allgäuer Alps, Northern Tyrol; 3. Rothornjoch, Allgäuer Alps, Northern Tyrol; 4. Grubalacke, Northern Tyrol

**1. ábra:** Mikroszkópos felvételek alpi „radiolaritok”-ról

### *A case in point: Alpine radiolarites*

Depending on the definition based on the percentage of included microfossils, not all shown examples in **Fig. 1** would be determined as “radiolarites”. The chert banks of the Rothornjoch (No. 3 and 4) barely carry more than 50% radiolarian in the visible spot under the reflected light microscope (20x magnification). And there is more to it than that: from experience every raw material scientist knows about the effect that in certain parts of chert banks the fossil content can be very high, whereas other parts lack those inclusions almost completely. Particularly in nodular cherts this can be easily observed at the regions towards

the cortex, where fossil remains regularly occur concentrated.

In the course of refitting archaeological artefacts, the grotesque situation of two raw material varieties coalesced in one nodule can emerge. The author has experienced this phenomenon himself, when a chert (without any visible inclusions at all) and a radiolarite (with approximately over 50% radiolarian content) perfectly matched.

This underlines the urgent needs of a terminology system that is at the same time easy to handle and produces accurate results. Of course not every insecurity in raw material detection will be clarified applying the Classification System, accuracy will



definitely increase with strict adherence to it though.

Guide to the usage of the Chert Group Classification System (see **Appendix, Tables 2 and 3**)

All parameters defined above are evaluated in the Chert Group Classification System. The categories which are typical for members of the chert group are itemised in the tables according to their relevance for a raw material analysis. The analysis is structured in a multiple choice model, the majority of positive matches define the questionable affiliation of sedimentary, organically formed SiO<sub>2</sub> raw materials.

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**Appendix****Table 1.:** Lithic raw materials used for stone tool production. Chert Group Classification System I: Chert**1. táblázat:** Kőeszköz készítésre használt nyersanyagok rendszerezése

|                |   |  |  |  |                        |
|----------------|---|--|--|--|------------------------|
| Opal           | historic  | mineral  | metamorphic,<br>sedimentary or<br>hydrothermal | amorph,<br>teilkristallin                  | inorganic /<br>organic |
| Petrified wood | after source<br>material                          | mineral<br>(if petrified as<br>quartz or opal) | Pseudomorpha<br>sis                            | depending on<br>petrifying<br>material     | inorganic /<br>organic |
| Obsidian       | historic name<br>of a person<br>( <i>Obsius</i> ) | igneous glass                                  | igneous  | amorphous,<br>rarely partly<br>crystalline | inorganic              |
| Tectite        | after event                                       | impact glass                                   | impact of a<br>meteorite                       | amorphous                                  | inorganic              |
| Quartzite      | after source<br>material                          | rock   | metamorphic                                    | rough- fine-<br>crystalline                | inorganic              |

**Table 2.:** Classification system for members of the chert - group.

**2. táblázat:** Kőeszköz készítésre használt nyersanyagok rendszerezése - kovaközetek

|                     |                     |                                |                             |                            |
|---------------------|---------------------|--------------------------------|-----------------------------|----------------------------|
| Genesis             |                     | <b>generally jurassic</b>      | <b>sometimes cretaceous</b> |                            |
| Fissures            | yes                 | often                          |                             |                            |
|                     | no                  | rarely                         |                             |                            |
| Fracture properties | conchoidal - smooth |                                |                             |                            |
|                     | amorphously - rough |                                |                             |                            |
| Granularity         |                     | very rough - very fine grained |                             |                            |
| Carbonate content   | yes                 | not always detectable          |                             |                            |
|                     |                     | highly calcareous              |                             | <b>siliceous limestone</b> |

|                               |                            |  |              |                                       |        |             |
|-------------------------------|----------------------------|--|--------------|---------------------------------------|--------|-------------|
| Matrix                        | silicified                 |  |              |                                       |        |             |
| Inclusions                    | fossil                     | Fossil type  | Count        |                                       |        |             |
|                               |                            |  | 0%           | < 10%: Index fossilisation detectable |        |             |
|                               |                            | A.a Radiolaria   | <b>chert</b> | <b>radiolarite</b>                    |        |             |
|                               |                            | A.b Spicula  | <b>chert</b> | <b>spiculite</b>                      |        |             |
|                               |                            | A.c Sponges remains  | <b>chert</b> | <b>spongiolite (spongilite)</b>       |        |             |
|                               |                            | A.d Crinoidea  | <b>chert</b> | stays <b>chert</b>                    |        |             |
|                               |                            | A.e Foraminifera   | <b>chert</b> | stays <b>chert</b>                    |        |             |
|                               |                            | A.f Seashells  | <b>chert</b> | stays <b>chert</b>                    |        |             |
|                               |                            | A.g Detritus   | <b>chert</b> | stays <b>chert</b>                    |        |             |
|                               | non - fossil               | Type   | count        |                                       |        |             |
|                               |                            |  | none         | some                                  | many   | very many   |
|                               |                            | A.a. Heavy minerals (garnett, tourmaline,...)                            | x            | x                                     | x      | rarely      |
|                               |                            | A.b. Mica  | x            | x                                     | x      | rarely      |
|                               |                            | A.c. Quartz geodes   | x            | x                                     | x      | x           |
|                               |                            | A.d. SiO <sub>2</sub> - precipitations                                   | x            | x                                     | rarely | very rarely |
| A.e. Various foreign minerals | x                          | x  | x            | x                                     |        |             |
| none                          | no (detectable) inclusions |  |              |                                       |        |             |
|                               |                            | metamorphic genesis<br>layered structure<br>black colour<br>dense matrix |              | <b>Lydite</b>                         |        |             |

**Table 3.:** Classification system for flint**3. táblázat:** Kőeszköz készítésre használt nyersanyagok rendszerezése - tűzkő

|                     |                               |   |          |                   |                   |           |
|---------------------|-------------------------------|---|----------|-------------------|-------------------|-----------|
| Genesis             |                               | <b>cretaceous</b>                             |          |                   |                   |           |
| Fissures            | yes                           | rarely  |          |                   |                   |           |
|                     | no                            | often   |          |                   |                   |           |
| Fracture properties |                               | conchoidal - smooth                           |          |                   |                   |           |
| Granularity         |                               | very fine grained                             |          |                   |                   |           |
| Carbonate content   | yes                           | in the cortex                                 |          |                   |                   |           |
|                     | no                            | in the matrix                                 |          |                   |                   |           |
| Matrix              |                               | very densely silicified                       |          |                   |                   |           |
| Inclusions          | fossil                        | Fossil type                                   | Count    |                   |                   |           |
|                     |                               |   | 0%       | many              | very many         |           |
|                     |                               | A.a Radiolaria                                | always   | never             |                   |           |
|                     |                               | A.b Spicula                                   | rarely   | often             | possible - rarely |           |
|                     |                               | A.c Sponges remains                           | rarely   | often             | possible - rarely |           |
|                     |                               | A.d Crinoidea                                 | often    | possible          | possible - rarely |           |
|                     |                               | A.e Foraminifera                              | often    | possible - often  | possible - rarely |           |
|                     |                               | A.f Seashells                                 | possible | possible - rarely | possible - rarely |           |
|                     |                               | A.g Detritus                                  | often    |                   | possible - rarely |           |
|                     | non fossil                    | Type  | Count    |                   |                   |           |
|                     |                               |   | none     | some              | many              | very many |
|                     |                               | A.a. Heavy minerals (garnett, tourmaline,...) | always   | never             | never             | never     |
|                     |                               | A.b. Mica                                     | always   | never             | never             | never     |
|                     |                               | A.c. Quartz geodes                            | possilbe | possible          | rarely            | rarely    |
|                     |                               | A.d. SiO2 - precipitations                    | often    | often             | possible          | possible  |
|                     | A.e. Various foreign minerals | possible                                      | rarely   | very rarely       | very rarely       |           |
|                     | none                          | no inclusions                                 |          |                   |                   |           |