# Occurrences and provenances of prehistoric hornfels polished stone tools in Hungary

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## Introduction

Hornfels is a fine grained contact metamorphic rock commonly used in the Carpathian Basin and its surroundings as raw material for polished stone artefacts, starting from the Early Neolithic onwards (e.g. Starnini and Szakmány 1998, Starnini et al. 2007).

Although hornfels stone tools are distributed on the whole territory of the Carpathian Basin, they dominate within the archaeological polished stone assemblages especially in its eastern part, with an increasing amount of occurrences toward the SE part of the Great Hungarian Plain (Szakmány 2009).

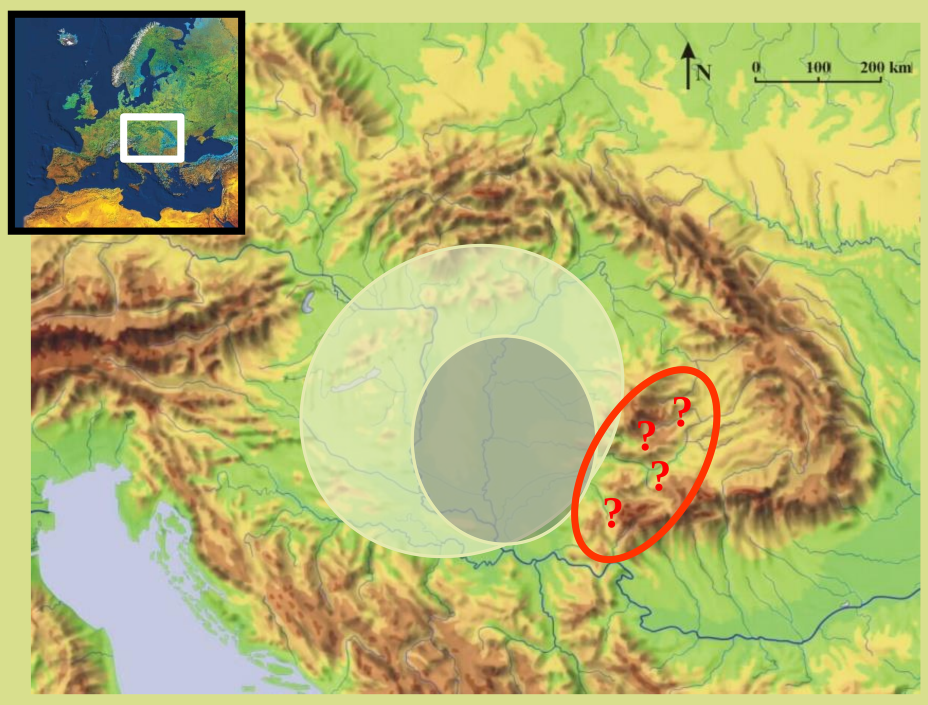
Hornfels is a very fine grained, greenish-grey, grey, massive, hard but tenacious raw material, indeed very good for producing polished stone axes/adzes blades due to its resistance to mechanical stress.

From a typological point of view, hornfels artefacts are mainly shoe last adzes, chisels, but also large axes, adzes and perforated adzes, often with very finely polished surfaces. The mechanical property of the fine-grained hornfels are in fact suitable for wood-working tools. The geological source of this raw material was unknown.

## Aims and goals

Our research had two goals:

1) It was aimed at characterizing the raw materials of the artefacts on the base of their petrological and geochemical properties with scientific methods.
2) Its challenging objective was to determine/localize the geological source and the exact provenance(s) of their raw materials combining archaeometric analyses and geological field survey.



*Distribution of hornfels stone tools in the Carpathian Basin (grey shades according to frequency) and supposed provenance area (red question marks)*

*Typology of hornfels polished Neolithic tools in Carpathian Basin*

*Hornfels boulders and large cobbles in the riverbeds at the outcrop zone: a creek near Novákfalva (Glimboca), SW Rusca Mts.*

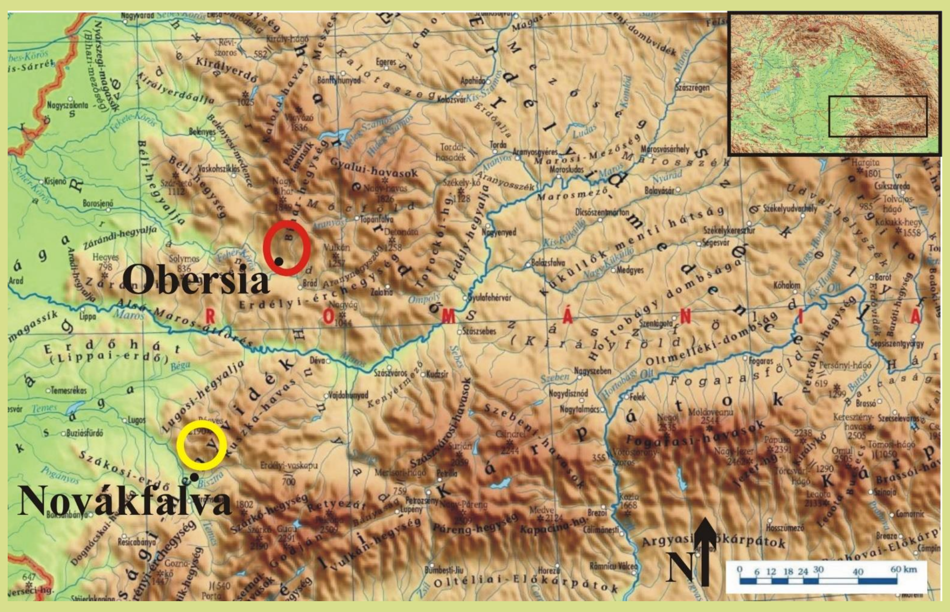
## Strategy for determining possible raw material sources

Since the distribution of hornfels Neolithic artefacts shows an increasing number of occurrences toward the SE part of the Great Hungarian Plain (Szakmány 2009) and considering the geological constraints, i.e. that hornfels is a metamorphic rock formed in the contact zone of an igneous body, the geological survey was planned in the closest area where these conditions are encountered. It must be underlined that occurrences of such rocks were not known in the Carpathians from previous literature and the geological maps. For this reason we ***could only suppose that the source was generally localized in the SE Carpathians/Apuseni Mts.***

During fieldwork research, conducted examining carefully the coarse sediments in the river beds, several rock samples have been collected for petrological analyses (Starnini et al. 2015). However, at the end, two localities, have been discovered where hornfels indeed very similar to the raw materials of the artefacts occur, namely:

**- Southwestern part of Rusca Mts. in Bistra river valley in the environs of the village Novákfalva (Glimboca).**
**- South Apuseni Mts. (around White Körös source); on a North-South valley near the village Obersia (Obârșa).**

The macroscopic characteristics of the sampled hornfels, very similar to those of the stone tools, are very fine-grained textures, grey-greenish-grey colours, high density and hardness. The surveyed areas are characterized by deep valleys in which the hornfels formation outcrops, however the raw material for the stone tools could be easily collected in the river beds in a larger geographical area in form of large or medium-sized cobbles/pebbles.



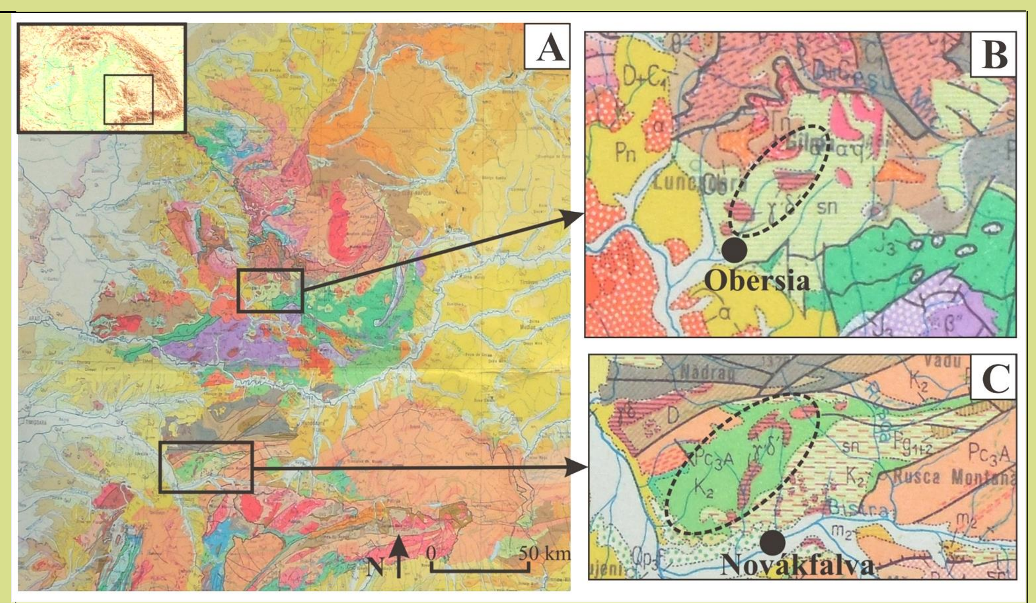

*Map of the surveyed area in SE Carpathians and S Apuseni Mts. where hornfels most similar to those of the Neolithic artifacts have been found (circles)*

*Geological map of the same area on the left (A) and details (B= S Apuseni Mts., N of Obersia; C= SW part of Rusca Mts., NW of Novákfalva) with the contact zones.*

*Dashed ovals outline the territories with hornfels.*

*Legend: green: Gosau facies sedimentary rocks; dark lilac-red : banatite intrusions.*

*Basic geological map: Sandulescu et al. (1978).*




## Materials and methods

Several Neolithic stone artefacts are complete, valuable object, often in museum displays, therefore they can be only analysed by non-destructive methods.

After macroscopic description and **Magnetic Susceptibility** (MS) measurements, we experimented two non-destructive analytical methods, namely the "**original surface investigation**", which is a type of **SEM-EDX analysis**, employed in order to determine the chemical composition of the rock forming minerals, including accessories, and characterize the texture of the rock (Bendő et al. 2012, 2013).

In addition, **Prompt Gamma Activation Analyses** (PGAA) have been performed for determining major elements and some traces ones in the bulk (Révay 2009, Szentmiklósi et al. 2010, Szakmány et al. 2011). Finally several samples of broken artefacts have been analyzed in **thin section** by petrographic (polarising) microscopy.

More than one hundred polished stone artefacts and 135 geological samples from the potential raw material sources collected during fieldwork have been investigated by the same methods up to now.

# RESULTS: COMPARISON OF STONE TOOLS AND ROCK SAMPLES

## Magnetic Susceptibility

Corrected magnetic susceptibility (MS) values (Bradák et al., 2009) of hornfels artefacts show a very narrow range of values, between $\chi_v = 0.2\text{-}0.4 \times 10^{-3}$ SI, whilst MS values from natural rock samples ranges between $\chi_v = 0.2\text{-}0.8 \times 10^{-3}$ SI, thus overlapping in a good reciprocal agreement.

## Microscopic petrography and SEM-EDX

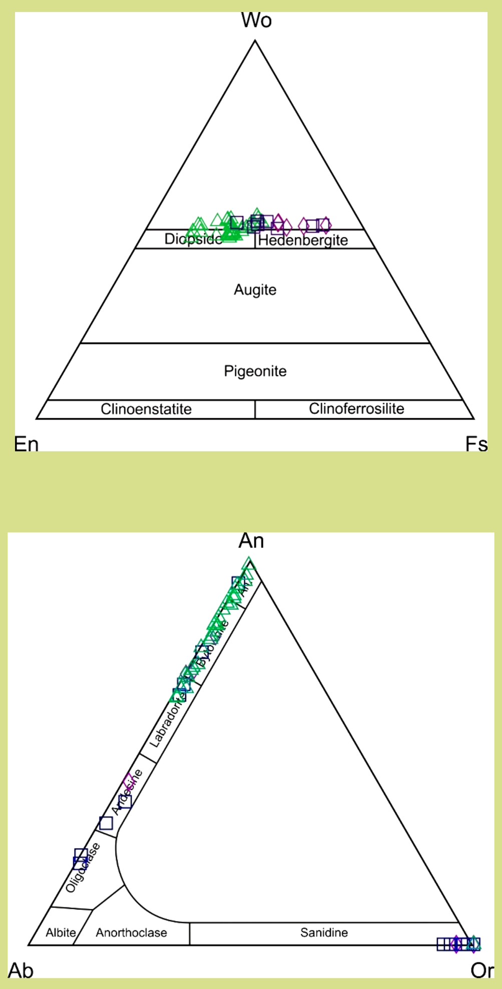
In thin section, hornfels is very fine grained, it has granoblastic or poikiloblastic texture. There is no, or only a weak schistosity.

The main constituents are diopside, basic plagioclase, less K-feldspar, rare scapolite and biotite. Accessories are apatite, titanite, allanite, zircon, and occasionally pyrrhotite and epidote.

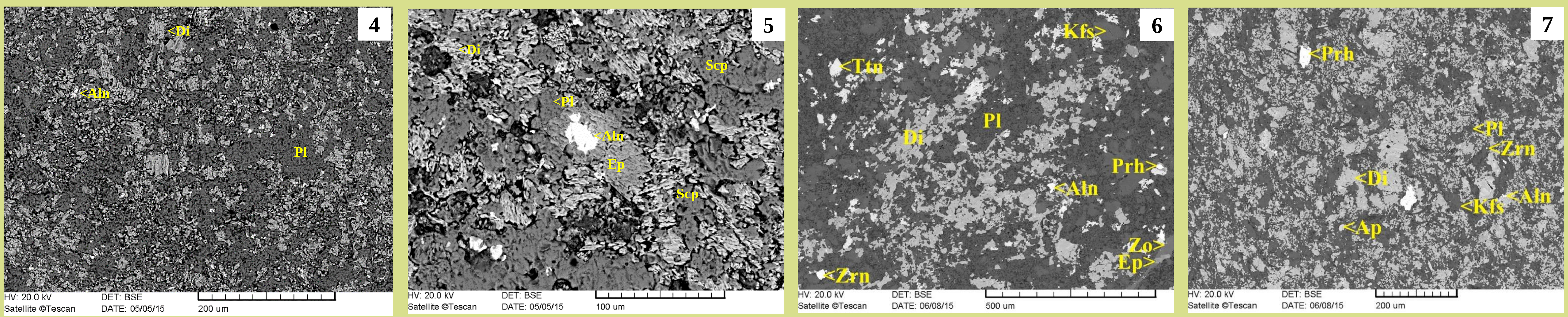
The main difference noticed in the rock samples is the varying amounts of very small and dispersed quartz particles, occasionally accumulated in bands. This probably indicates the presence of fine-grained sand content and clay layers in the original calcareous rock suffering contact metamorphism, and what was left as relict. The sizes of the rock particles varied, and banding of coarser particle was observed too.

It should be stressed that quartz was never observed in the stone tools samples so far analysed, however, also some geological samples have no quartz content.

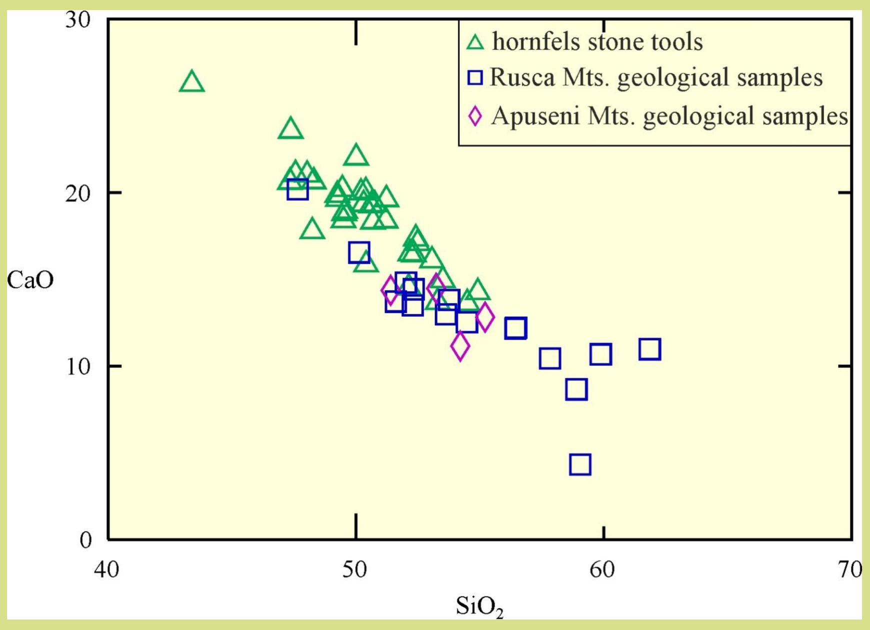

*Microphotographs of hornfels Neolithic polished tools (1=GOR-241, Gorzsa tell) and rock samples (2=sample T-14/1b, Rusca Mts.; 3=sample FHK-12/9, S. Apuseni Mts.)*




*Composition of pyroxenes (above) and feldspars (bottom) of hornfels rock samples and Neolithic polished tools (for symbols see below).*




*BSE images of original surface investigation by SEM-EDX of hornfels Neolithic polished tools (4=sample GOR-225; 5=sample GOR-323 both from Gorzsa tell) and rock samples (6=sample T-28/5, Rusca Mts.; 7=sample FHK-8/11, S. Apuseni Mts.) (abbreviations: Aln=allanite ; Ap=apatite; Di=diopside; Ep=epidote; Kfs=K-feldspar; Pl=plagioclase; Prh= pyrrhotite; Scp=scapolite ; Ttn= titanite; Zrn=zircon*




*Chemical composition of hornfels rock samples and Neolithic polished tools.*

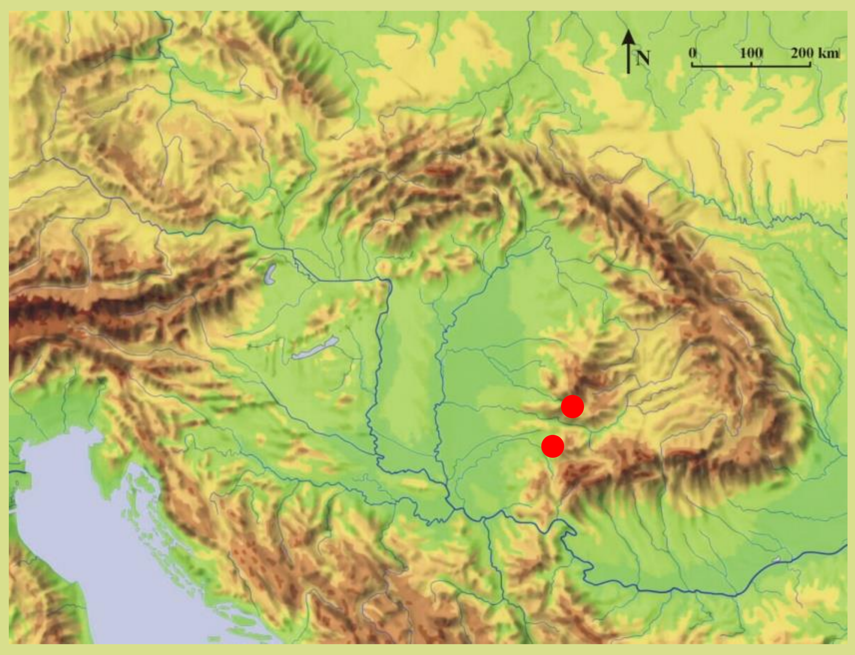
## Bulk rock chemistry

Hornfels artefacts have high CaO (dominantly range 13-23 m%) and relatively high $Al_2O_3$ content (dominantly range 13-16 m%), the alkalis ($Na_2O+K_2O$) occur only in few amount (dominantly range 1-5 m%).

The chemical composition of the natural rock samples in respect to that of the stone tools is somewhat more diversified, showing broader limits. The CaO content is high (predominantly from 10 to 14% w/w), although the majority of the stone tools samples show slightly higher values. The $SiO_2$ content is between 47-61 m/m%, but mostly around 50 m/m%, and $Al_2O_3$ content is 13-19 m/m%, both in good agreement with the values displayed by the stone tools. The rocks alkali content ($Na_2O+K_2O$) is usually 3-6 m/m%, slightly higher than that of the stone tools.

## CONCLUSIONS AND RESULTS

- Polished stone tools made of fine grained contact metamorphic rocks were widespread in the Carpathian Basin during the Neolithic.
- The geological source of hornfels was previously unknown. **We could localize two areas where hornfels occur**: in the Rusca Mts. and the South Apuseni Mts. In both territories hornfels formed on the contact zone of subvolcanic intermediate-acidic rocks (so called Banatite) and high Ca-content clayish Cretaceous Gosau-facies sediments (possible marl).
- The wider compositional range of the geological samples of hornfels and a narrower one showed by the artefacts suggests that **prehistoric people carefully selected the polished stone tools' raw materials**.



*Map of the Carpathian Basin with the location of the two hornfels sources discovered during our research (red dots)*

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