ARCHAEOMETRIC ANALYSES OF ADZE-BLADES FROM NUKU HIVA, MARQUESAS ISLANDS

NUKU HIVÁRÓL (MARQUESAS SZIGETEK) SZÁRMAZÓ KŐESZKÖZÖK ARCHEOMETRIAI VIZSGÁLATI EREDMÉNYEI •

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Abstract

In this paper we present our results based on detailed archaeometric (mineralogical, petrological and geochemical) investigations on two flakes, originated from Nuku Hiva, Vaitehii I and Ha'ahinani sites. The main aim of these researches was to determine and characterise the raw material of the stone tools and determine or at least outline their provenances. Based on the mineralogical composition and texture the flake origined from Vaitehii I are basalt and it is very similar to the local Tekao type tholeiitic basalt. On the contrary the raw materials of the flake origined from Ha'ahinani is phonolite, its provenance is Ua Pou island.

Kivonat

Munkánk során két Nuku Hiva-i lelőhelyről (Vaitehii I és Ha'ahinani) származó kőeszköz töredéken végeztünk archeometriai (ásványtani, kőzettani és geokémiai) vizsgálatokat. Fő célunk a töredékek nyersanyagának pontos meghatározása és származásuk körvonalazása volt. Eredményeink alapján a Vaitehii I lelőhelyről származó kőeszköz bazaltból készült, és összetétele jól egyezik a helyi Tekao típusú tholeiites bazalttéval. A Ha'ahinani öbölből származó kőeszköz nyersanyaga fonolit, a nyersanyagának származási területe Ua Pou szigete.

KEYWORDS: POLYNESIA, BASALT, PHONOLITE, HALF-PRODUCTS, ARCHAEOMETRIC EXAMINATION OF THE RAW MATERIAL

KULCSSZAVAK: POLINÉZIA, BAZALT, FONOLIT, FÉLKÉSZ ESZKÖZÖK, NYERSANYAG-VIZSGÁLAT

Introduction

Stone artefacts and their raw material from the Marquesas Islands, part of French Polynesia were in the focus of scientific interest for a long time (see e.g. McAlister & Allen 2017). In 1998, Judit Antoni and Alfred Falchetto performed field surveys on Nuku Hiva, one of the Marquesas Islands and collected numerous lithic artefacts there. Part of the material is presented in this volume (Antoni & Falchetto 2021). In our study, we present here the results of the investigation of two stone artefacts from the sites Vaitehii and Ha'ahinani-bay, respectively. For the sampling localities, see the Fig 1. of Antoni & Falchetto (2021 in this volume). NUH-V1 stone tool flake was collected in Vaitehii site, from the pit on the hills in the Western-Northwestern part of Nuku Hiva. There are a lot of flakes in this pit where raw materials of polished stone tools were extracted 200-300 years ago. The elongated, triangular shaped dark-grey coloured flake has wavy and rugged edge on both of its rims as traces of knapping. Its cross-section at the base, by the bulbus is also triangular. On its tip there are rests of cortex. Dimensions: length: 10.2 cm, width: 3.3-4.8 cm, thickness: 0.7-1.4 cm, weight: 26.0 g. (**Fig. 1.**)

NUH-H1 stone tool flake has been collected from the surface in the eastern side of Ha'ahinani-bay of Western-Northwestern part of Nuku Hiva which is not too far from Vaitehii. The NUH-H1 flake has some traces of knapping on its surface. Also there is a rugged edge on its concave side due to knapping.

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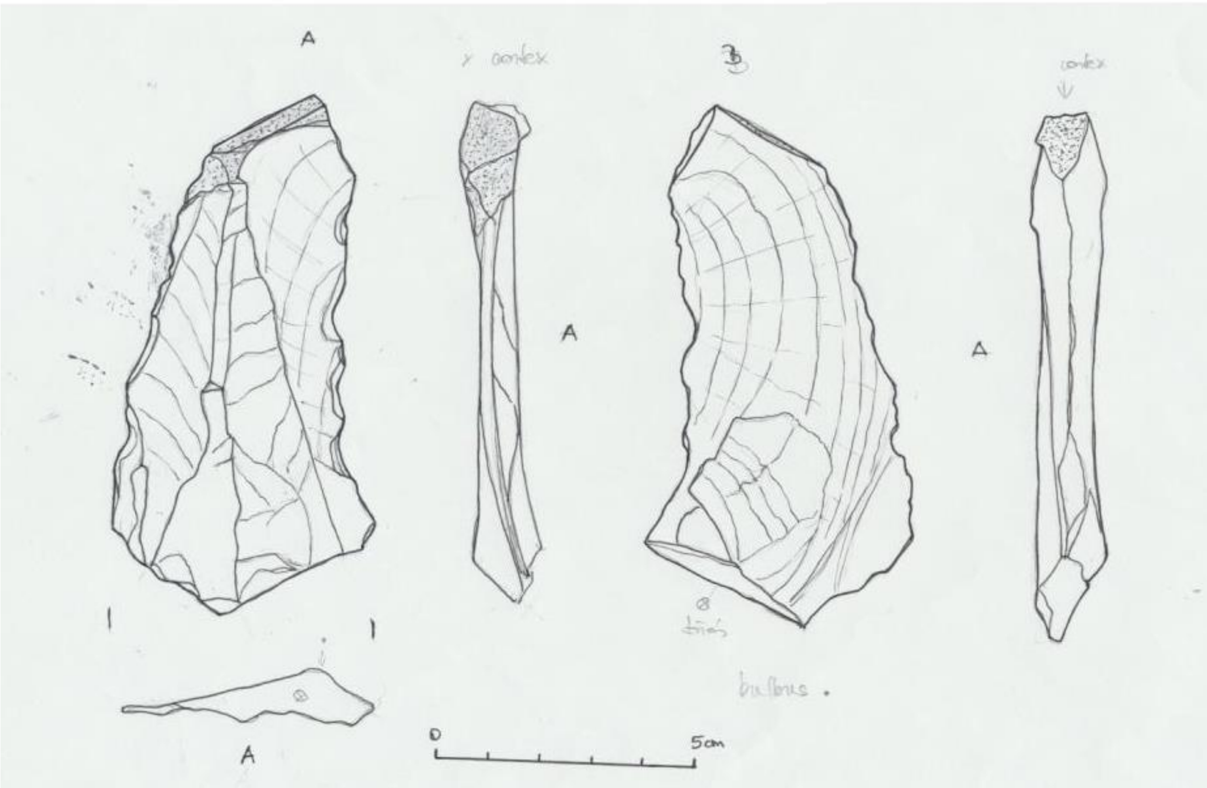
Fig. 1.:
Stone flake analysed form Vaitehii I.

1. ábra:
A vizsgált Vaitehii I. lelőhelyről származó félkész kőpenge

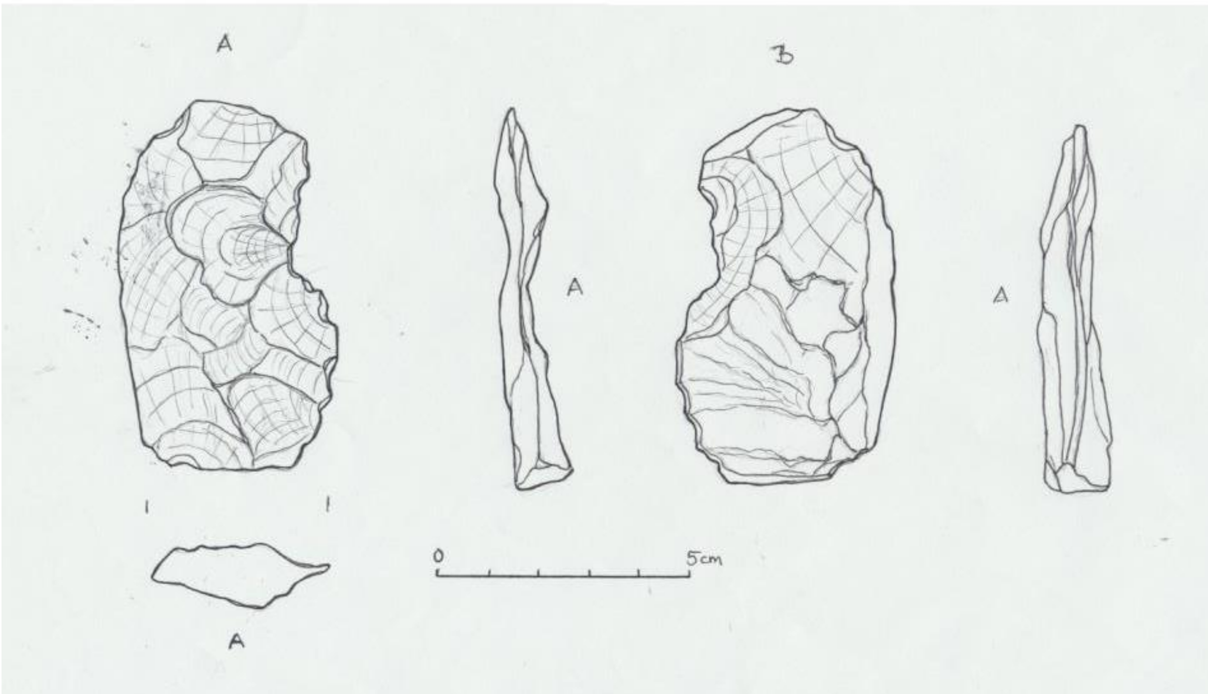


The slightly convex side of the flake shows possible traces of retouch process. Dimensions: length: 7.4 cm, width: 4.2 cm, thickness: 0.5-1.2 cm, weight: 16.0 g. (**Fig. 2.**)

Mineralogical, petrological and geochemical investigation have been made on both polished stone flakes. The main aim of the archaeometric investigation was to determine and characterise the raw materials of the stone tools and determine or at least outline their provenance.

Fig. 2.:
Stone flake analysed form Ha'ahinani Bay

2. ábra:
A Ha'ahinani öbölből származó vizsgált kőpenge



Moreover, we were trying to find answer to the following questions:

1) How does the chemical composition of sample NUH-V1 match with the composition of local basalt?

2) Is the chemical composition of the piece NUH-H1 similar, or different from NUH-V1, in other words, did they use the same raw material or not?

Methods

Both stone tools were macroscopically described and the magnetic susceptibility (MS) of their material was measured. These data give a preliminary information about the main type of the raw materials of the stone tools. Methodology of MS measurements and the calculation / determination of the real MS values are based on Williams-Thorpe and Thorpe (1993), Bradák et al. (2009), Szakmány et al. (2011b).

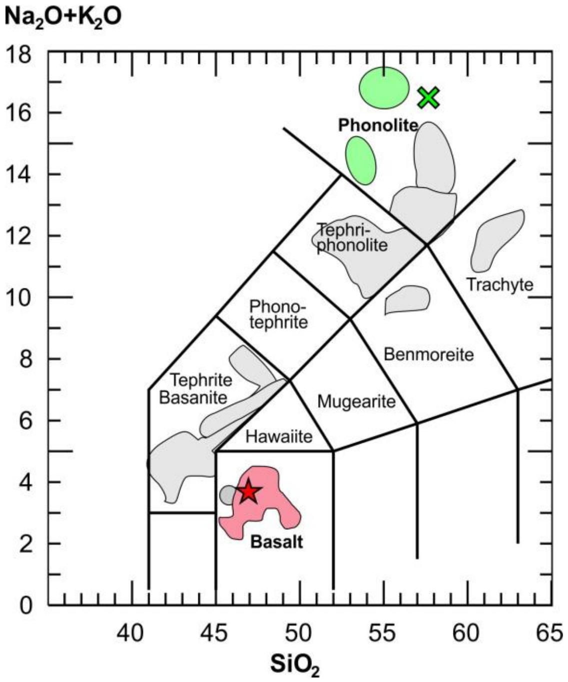


Fig. 3.: TAS diagram (SiO_2 vs Na_2O+K_2O) of the analysed flakes. Green cross – NUH-H1 stone flake; red star – NUH-V1 stone flake. For comparison bulk rock composition of Ua Pou and Nuku Hiva lavas from Legendre et al. 2005a, 2005b are also shown, Green ellipses – group C and D phonolites (combined), grey areas – other rock types of Ua Pou; pink area – olivine tholeiite of the Tekao volcano (Nuku Hiva).

3. ábra: A vizsgált minták elhelyezkedése a TAS diagramon. Zöld kereszt – NUH-H1, vörös csillag – NUH-V1. Összehasonlító adatok Legendre 2005a, 2005b alapján: zöld mező – C és D típusú fonolitok, szürke mező - egyéb kőzettípusok (Ua Pou); rózsaszín mező – Tekano típusú olivin tholeiit (Nuku Hiva)

As it was allowed to cut small pieces from both flakes, thin sections were made from them to perform detailed polarizing microscopic petrographic descriptions. Additional petrographic investigation and in situ mineralogical analyses were performed with an Amray 1830 type electron-microscope equipped with EDAX PV9800 energy dispersive spectrometer at the Department of Petrology and Geochemistry, Eötvös Loránd University, Budapest. Exact parameters of SEM-EDX measurements can be found in Bendő et al. (2019).

Non-destructive elemental analyses were carried out by Prompt Gamma Activation (PGAA) at the Budapest Neutron Centre. This method determines the bulk concentrations most of the major elements and some trace elements (B, Cl, Sc, V, Nd, Sm and Gd). The principle of the quantitative analysis is given by Révay 2009. Detailed description of the experimental setup is given by Szentmiklósi et al. (2010). The application of PGAA for provenance of stone tools is discussed in Szakmány et al. (2011a) and Bendő et al. (2019).

Results

On the macroscopic scale, both studied polished stone flakes are very fine grained. They show black colour on the fresh break, and brownish-grey on their weathered surfaces. The flake of NUH-V1 contains few slightly elongated or almost isometric green olivine crystals with a maximum size of 2 mm. The NUH-H1 stone tool flake contains sparse small sized (max. 1 mm) white, almost idiomorphic tabular feldspar crysts. The groundmass of both stone tools is very fine grained, only some very small sized white and black grains are visible, which cannot be specified by the naked eye.

The real MS values of the stone tools are close to each other: 6,57 x10^{-3} SI (NUH-V1) and 5,97 x10^{-3} SI (NUH-H1), respectively, which generally correspond the MS values of basic-intermediate volcanic rock types.

Table 1.: Major (wt%) and some trace (ppm) elements content of studied Nuku Hiva flakes

1. táblázat: A vizsgált Nuku Hiváról származó kőeszözök fő-(wt%) és nyomelem (ppm) tartalma

	NUH-V1	NUH-H1
	basalt	phonolite
SiO_2	46.5	57.2
TiO_2	3.26	0.30
Al_2O_3	12.9	20.7
Fe_2O_3*	12.7	2.8
MnO	0.15	0.24
MgO	10.3	<QL
CaO	9.6	1.6
Na_2O	2.61	9.33
K_2O	1.08	7.04
H_2O	0.87	0.45
Total	99.91	99.68
B	2.22	19.10
Cl	108	3072
Sc	25.3	0
V	369	0
Nd	39.4	61.0
Sm	6.88	5.16
Gd	6.99	3.55

QL - quantification limit; * - total Fe-content

Based on the chemical analysis, NUH-V1 has a basic composition with 46 wt% SiO_2 content. Moreover NUH-H1 has higher SiO_2 content (57 wt%), which shows its intermediate composition. The TiO_2 content of the NUH-V1 is quite high, whereas the sum of alkali elements is low, especially K_2O. On the contrary the sum alkalis of the NUH-H1 is very high (Na_2O higher than 9 wt%, K_2O higher than 7 wt%), showing the strong alkaline character of this rock (**Table 1., Fig. 3.**) The chemical composition fits very well to the mineralogical composition of both stone tools.

On the microscopic scale, sample NUH-V1 has porphyritic microholocrystalline texture, with local concentrations of coarser grained crystals. The porphyric constituents are skeletal olivine with generally fresh core and iddingsitic rim, dominantly 250-300 µm (max 650 µm) in size. Cr-spinell and orthopyroxene inclusion are very rare or absent. The groundmass is very fine grained (generally 100-200 µm), completely crystallized with slightly fluidal structure. It dominantly consists of elongated intermediate-basic plagioclase (andesine-labradorite) and hipidiomorphic, slightly elongated and zoned augitic clinopyroxene with Al-rich core and Al-poor rim. Occasionally coarser grained plagioclase crystals occur. Very fine grained (50-100 µm) opaque minerals are abundant: those are dominantly ilmenite, occasionally with a magnetite rim. Scarce phlogopite crystals appear mainly in the somewhat better crystallized parts of the groundmass or at the rims of olivine. (**Figs 4., 5., 6., 7., 12. and 13, Tables 2., 3., 4., 5., and 6.**) Based on the chemical and mineralogical composition and texture the NUH-V1 stone tool is basalt.

On the microscopic scale sample NUH-H1 has fine grained, porphyric microholocrystalline fluidal texture occasionally with coarse grained phencrysts of sanidine having strongly resorbed plagioclase (oligoclase) core. Fine grained, porphyric micro-holocrystalline fluidal texture with occasionally quite coarse grained phenocrysts of sanidine with strongly resorbed plagioclase (oligoclase) core. The groundmass is very fine grained (dominantly 30-80 µm), completely crystallized. It dominantly consists of elongated K-feldspar (sanidine) and hipidiomorphic nepheline. Slightly elongated brownish green-dark green pleochroic pyroxene crystals (with hedenbergite composition) and opaque minerals (Ti-magnetite) are also abundant. Few grains of sodalite and analcime can be observed, the analcime formed from altered nepheline. Accessories are apatite, sometimes with a monacite rim, and a peculiar, slightly elongated, fine grained pale purple Zr-rich phase which could be an eudialite-group mineral (probably a Ca-rich type sergevanite). Its small size makes the accurate determination impossible even with SEM-EDS (**Figs. 8., 9., 10., 11., 12. and 13., Tables 2., 3., 5., 7. and 8.**). Based on the chemical and mineralogical composition and texture the NUH-H1 stone tool is phonolite.

Fig. 4.: Polarizing microscopic photo of NUH-V1 basalt flake with olivine (ol) phenocrysts with fresh core and iddingsited rim, plagioclase (pl), augitic pyroxene (cpx) and phlogopite (phl) in the completely crystallized groundmass (crossed nicols)

4. ábra: A NUH-V1 bazalt kőeszköz polarizációs mikroszkópi képe, olivin (ol) fenokristály üde maggal és iddingzites szegéllyel, plagioklász (pl), augit (cpx) és flogopit (phl) teljesen kristályos alapanyagban (+N)

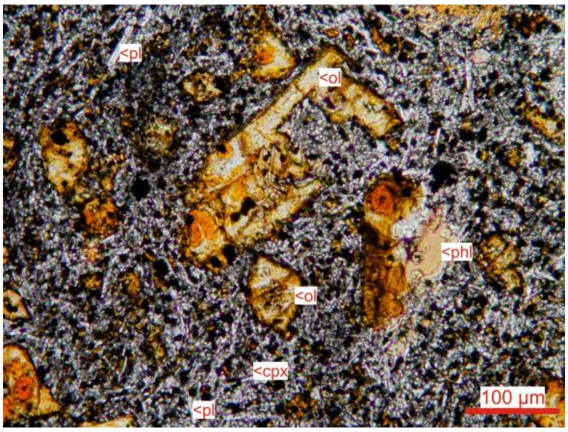


Fig. 5.: Polarizing microscopic photo of NUH-V1 basalt flake with iddingsited olivine (ol) phenocrysts and phlogopite (phl), plagioclase (pl) and augitic clinopyroxene (cpx) in the groundmass (plane polarized light)

5. ábra: A NUH-V1 bazalt kőeszköz polarizációs mikroszkópi képe. Olivin (ol) fenokristály üde maggal és iddingzites szegéllyel, plagioklász (pl), augit (cpx) és flogopit (phl) teljesen kristályos alapanyagban (1N)

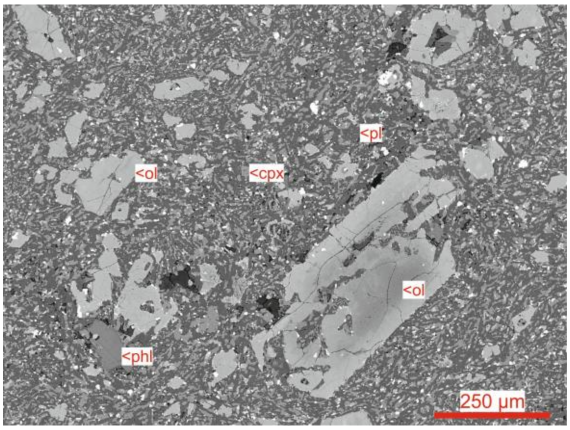


Fig. 6.: BSE image of NUH-V1 basalt flake on the same territory as in **Fig. 4.** Mineral abbreviations see in **Fig. 4.** caption

6. ábra: A NUH-V1 bazalt kőeszköz visszaszórt elektronképe a **4. ábrán** bemutatott területről. Rövidítéseket ld. a **4. ábránál**

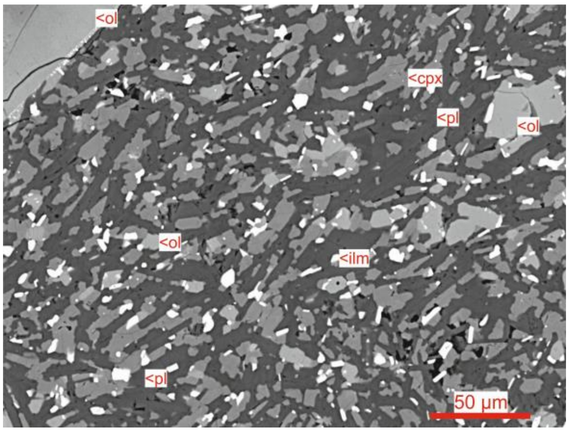


Fig. 7.: Groundmass of NUH-V1 basalt in BSE image. Abbreviations: cpx – clinopyroxene, ilm – ilmenite, ol – olivine, pl – plagioclase

7. ábra: A NUH-V1 bazalt alapanyagáról készült visszaszórt elektronkép Rövidítések: cpx – klinopiroxén, ilm – ilmenit, ol – olivin, pl - plagioklász

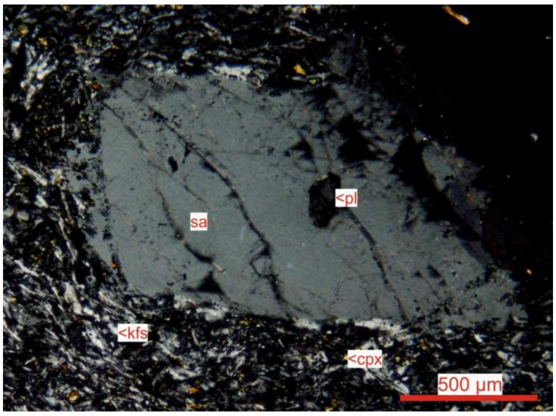


Fig. 8.: Polarizing microscopic photo of NUH-H1 phonolite flake. Large sanidine (sa) phenocryst with spongy rim and plagioclase (pl) inclusion in it, and fine grained fluidal groundmass. Abbreviations: kfs – K-feldspar, cpx - clinopyroxene (crossed nicols)

8. ábra: A NUH-H1 fonolit kőeszköz polarizációs mikroszkópi képe. Nagyméretű szanidin (sa) fenokristály szivacsos szövetű szegéllyel és plagioklász (pl) zárvánnyal, továbbá finom szemcsés, irányított (folyásos) szövettel. Rövidítések: kfs – káliföldpát, cpx – klinopiroxén (+N)

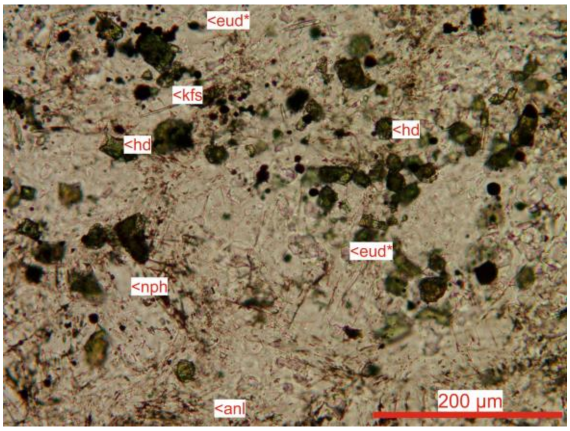


Fig. 9.: Polarizing microscopic photo of the goundmass of NUH-H1 phonolite flake. Fluidal texture with K-feldspar (sanidine – kfs), nepheline (nph), analcime (anl), hedenbergite (hd), and fine grained eudialyte group minerals (eud*). (plane polarized light)

9. ábra: A NUH-H1 fonolit kőeszköz alapanyagáról készült polarizációs mikroszkópi fotó. Folyásos szövetben káliföldpát (szanidin – kfs), nefelin (nph), analcim (anl), hedenbergit (hd), és finomszemcsés eudialit-csoportba tartozó ásvány (eud*) (1N)

Discussion

Macroscopic features of the two investigated flakes are very similar to each other, but the petrological and geochemical analyses have shown that their raw materials are different.

On the basis of mineralogical and chemical composition the **NUH-V1** flake is fine grained **basalt**. The porphyritic constituents are small and they have the same size range. The groundmass is completely crystallized. These properties signs that it has a very high quality as stone tool raw material. The mineralogy and the major element chemical composition of the basalt show tholeiitic character. Its chemistry fits very well to the tholeiitic basalt data set measured in Nuku Hiva. (Legendre et al 2005b). Nevertheless tholeiitic basalts are widespread in Marquesas archipelago. McAlister et al. (2017) summarised their chemical composition, moreover they analysed several stone tools.

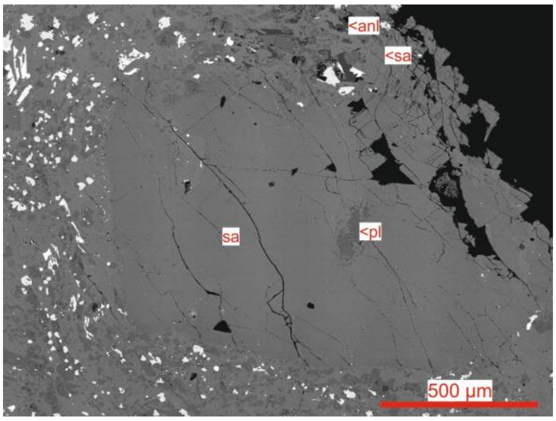


Fig 10.: BSE image of NUH-H1 phonolite on almost the same territory as in **Fig. 8.** Mineral abbreviations: sa – sanidine, pl – plagioclase, anl – analcime

10. ábra: A NUH-H1 fonolit kőeszköz alapanyagáról készült visszaszórt elektronkép, közelítőleg a **8. ábrán** bemutatott területről. Rövidítések: sa – szanidin, pl – plagioklász, anl - analcim

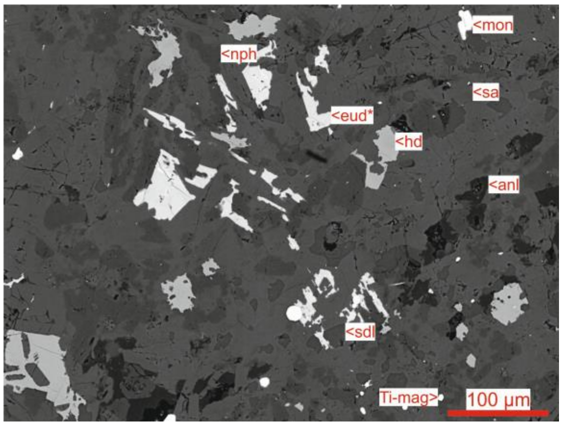


Fig. 11.: Groundmass of NUH-H1 phonolite flake in BSE image. Abbreviations: anl – analcime, eud* - eudialyte group mineral, hd – hedenbergite, mon – monazite, nph – nepheline, sa – sanidine, sdl – sodalite, Ti-mag – titano-magnetite

11. ábra: A NUH-H1 fonolit kőeszköz alapanyagáról készült visszaszórt elektronkép. Rövidítések: anl – analcim, eud* - eudialit csoportbeli ásvány, hd – hedenbergit, mon – monacit, nph – nefelin, sa – szanidin, sdl – szodalit, Ti-mag – titano-magnetit

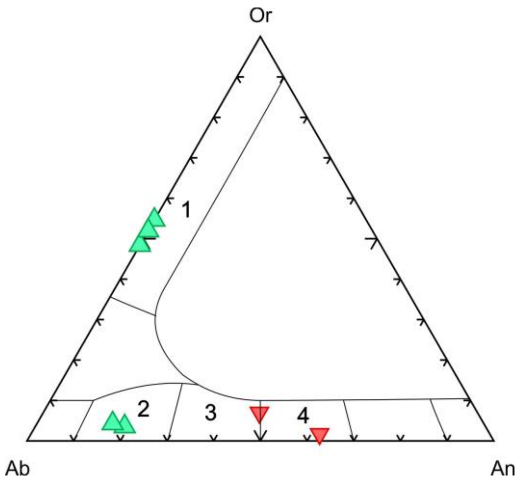


Fig. 12.: Feldspar compositions of NUH-V1 basalt flake (red triangle) and NUH-H1 phonolite flake (green triangle): 1: sanidine, 2: oligoclase, 3: andesine, 4: labradorite.

12. ábra: A NUH-V1 bazalt (vörös háromszög) és a NUH-H1 fonolit (zöld háromszög) kőeszközök földpátjainak összetétele: 1: szanidin, 2: oligoklász, 3: andezin, 4: labradorit.

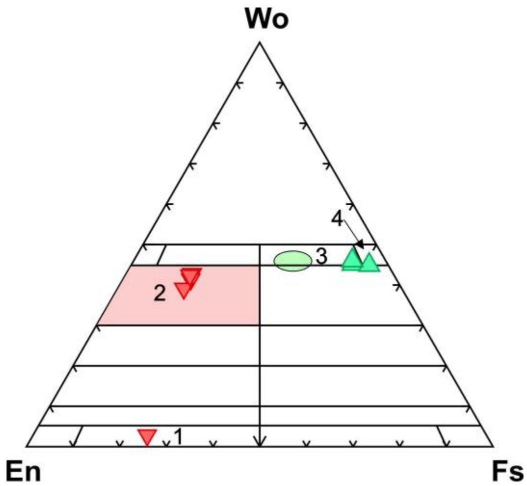


Fig 13.: Pyroxene composition of NUH-V1 basalt (red triangles) and NUH-H1 phonolite (green triangles) flakes. Basaltic sample contains clinopyroxene (2: Mg-rich augite) and – as inclusions in olivine - orthopyroxene (1: Ferroan-enstatite), whereas phonolite contains only clinopyroxene (3: Mg-hedenbergite, 4: hedenbergite). For comparison compositional range of clinopyroxenes of peralkaline phonolites from Ua Pou (pale green ellipsoide) and Tekao tholeiites of Nuku Hiva (pale red rectangle) are shown (based on Legendre et al. 2005a and 2005b, respectively).

13. ábra: A NUH-V1 bazalt (vörös háromszög) és a NUH-H1 fonolit (zöld háromszög) kőeszközök piroxénjeinek összetétele. A bazalt klinopiroxént (2: Mg-gazdag augit) és – olivinben zárványként – rombos piroxént (1: Ferro-ensztatit) tartalmaz. A fonolitban csak klinopiroxén (3: Mg-hedenbergit, 4: hedenbergit) fordul elő. Összehasonlító adatok: klinopiroxén Ua Pou peralkáli fonolitban (halvány zöld mező) és Nuku Hiván a Tekao tholeiitben (halvány vörös mező) (Legendre 2005a, illetve 2005b alapján).

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Table 2.: Feldspar compositional data of NUH-V1 basalt and NUH-H1 phonolite flakes

2. táblázat: A NUH-V1 bazalt és a NUH-H1 fonolit kőeszközök földpátjainak összetétele

Sample	**NUH-V1**	**NUH-V1**	**NUH-H1**	**NUH-H1**	**NUH-H1**	**NUH-H1**	**NUH-H1**
Rock type	basalt	basalt	phonolite	phonolite	phonolite	phonolite	phonolite
Position	G	G	C	C	C	R	G
name	pl	pl	pl	pl	kfs	kfs	kfs
SiO_2	53.06	55.13	62.07	62.92	65.75	65.59	66.14
Al_2O_3	28.90	27.73	23.82	23.28	19.78	19.53	19.38
FeO*	1.56	0.82	0.00	0.00	0.00	0.00	0.00
CaO	12.22	9.69	4.18	3.52	0.00	0.00	0.00
Na2O	3.98	5.40	9.30	9.51	5.12	6.14	5.48
K2O	0.28	1.23	0.64	0.77	9.35	8.74	9.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Cations							
Si	2.42	2.50	2.76	2.79	2.97	2.96	2.98
Al	1.55	1.48	1.25	1.22	1.05	1.04	1.03
Fe	0.06	0.03	0.00	0.00	0.00	0.00	0.00
Ca	0.60	0.47	0.20	0.17	0.00	0.00	0.00
Na	0.35	0.47	0.80	0.82	0.45	0.54	0.48
K	0.02	0.07	0.04	0.04	0.54	0.50	0.52
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00
endmembers							
Ab	36.46	46.70	77.30	79.50	45.42	51.64	48.06
An	61.86	46.31	19.20	16.26	0.00	0.00	0.00
Or	1.69	7.00	3.50	4.24	54.58	48.36	51.94

Oxides in wt%; * - total Fe-content
Position: G - groundmass mineral, C - core, R - rim
Name: pl - plagioclase, kfs - K-feldspar
Endmembers: Ab - albite, An - anorthite, Or - orthoclase

Table 3.: Pyroxene compositional data of NUH-V1 basalt and NUH-H1 phonolite flakes

3. táblázat: A NUH-V1 bazalt és a NUH-H1 fonolit kőeszközök piroxénjeinek összetétele

Sample	**NUH-V1**	**NUH-V1**	**NUH-V1**	**NUH-V1**	**NUH-V1**	**NUH-V1**	**NUH-H1**	**NUH-H1**	**NUH-H1**
rock type	basalt	basalt	basalt	basalt	basalt	basalt	phonolite	phonolite	phonolite
Position	G	G	G	G	G	G	G	G	G
Name	aug	aug	aug	aug	aug	opx	hed	hed	hed
SiO_2	48.73	48.31	48.16	52.00	51.21	53.70	47.19	48.22	46.53
TiO_2	2.63	2.54	2.53	1.36	1.65	0.00	0.65	0.33	1.18
Al_2O_3	5.78	8.33	8.56	3.16	3.81	2.71	2.23	1.68	2.84
MgO	14.81	13.76	13.8	16.07	14.89	26.35	2.33	1.26	2.21
FeO*	8.71	8.09	7.98	8.70	8.41	15.82	23.63	25.25	23.65
MnO	0.00	0.00	0.00	0.00	0.00	0.00	2.52	2.66	2.15
CaO	19.34	18.97	18.97	18.71	20.04	1.42	19.48	19.18	19.79
Na_2O	0.00	0.00	0.00	0.00	0.00	0.00	1.98	1.42	1.65
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Cations									
Si	1.81	1.80	1.79	1.93	1.90	1.94	1.88	1.95	1.86
Al4	0.19	0.20	0.21	0.07	0.10	0.06	0.12	0.05	0.14
Al6	0.06	0.16	0.16	0.06	0.07	0.05	0.00	0.03	0.00
Fe3	0.00	0.00	0.00	0.00	0.00	0.01	0.25	0.11	0.20
Ti	0.07	0.07	0.07	0.04	0.05	0.00	0.02	0.01	0.04
Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.82	0.76	0.76	0.89	0.82	1.42	0.14	0.08	0.13
Fe2	0.27	0.25	0.25	0.27	0.26	0.47	0.54	0.74	0.59
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.07
Ca	0.77	0.76	0.75	0.74	0.80	0.05	0.83	0.83	0.85
Na	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.11	0.13
mg#(fe2)	0.75	0.75	0.76	0.77	0.76	0.75	0.20	0.09	0.18
mg#(fe_tot)	0.75	0.75	0.76	0.77	0.76	0.75	0.15	0.08	0.14
endmembers									
En	44.08	43.09	43.24	46.71	43.78	72.70	7.51	4.10	7.15
Wo	41.38	42.70	42.73	39.10	42.35	2.82	45.14	44.87	46.00
Fs	14.54	14.21	14.03	14.19	13.87	24.49	47.35	51.03	46.86

Oxides in wt%; * - total Fe-content
Position: G - groundmass mineral
Name: aug - augite. opx - orthopyroxene. hed - hedenbergite
Endmembers: En - enstatite. Wo - wollastonite. Fs - ferrosillite

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Table 4.: Olivine compositional data of NUH-V1 basalt flake

4. táblázat: A NUH-V1 bazalt kőeszköz olivinjének összetétele

Sample	**NUH-V1**	**NUH-V1**	**NUH-V1**
Rock type	basalt	basalt	basalt
Position	C	R	C
Name	ol	ol	ol
SiO_2	36.22	34.67	33.32
Al_2O_3	0.00	1.24	1.80
FeO	21.90	38.90	42.25
MnO	0.25	0.33	0.28
MgO	41.34	24.41	22.06
CaO	0.29	0.44	0.30
Total	100	100	100
Cations			
Si	0.95	0.98	0.96
Al	0.00	0.04	0.06
Fe	0.48	0.92	1.02
Mn	0.01	0.01	0.01
Mg	1.61	1.03	0.95
Ca	0.01	0.01	0.01
mg#(fe_tot)	0.77	0.53	0.48
endmembers			
Fo	77.09	52.79	48.20
Fa	22.91	47.21	51.80

Oxides in wt%
Position: C - core, R - rim
Name: ol - olivine
Endmembers: Fo - forsterite, fa - fayalite

On the base of McAlister et al. (2017) results, basalts occurring in other territories of Nuku Hiva and the other islands of the Marquesas archipelago have different chemical composition. The best analogies by chemical composition to our basalt flakes are the basaltic dykes from Henua Ataha, which is occur in the North-western part of Nuku Hiva, the same territory as of the locality of flake NUH-V1. The MgO content is generally lower in the tholeiitic basalts of the whole archipelago as in the analysed sample except of Henua Ataha dyke. Even the basalt stone tools that occur in Eiao island and the basaltic rocks of the island which are the best quality basalts to make stone tools in Marquesas islands differ in chemical composition from the studied NUH-V1 basalt. Therefore the mineral composition and the appearance of the analysed basalt flake fits pretty well to the tholeiitic basalts occurring in Nuku Hiva.

Table 5.: Oxide minerals compositional data of NUH-V1 basalt and NUH-H1 phonolite flakes

5. táblázat: A NUH-V1 bazalt és a NUH-H1 fonolit kőeszközök oxid ásványainak összetétele

Sample	**NUH-V1**	**NUH-V1**	**NUH-V1**	**NUH-H1**
Rock type	basalt	basalt	basalt	phonolite
Position	I	G	G	G
Name	sp	sp	sp	Ti-mt
SiO_2	0.89	4.24	2.53	
TiO_2	17.82	6.98	9.26	14.92
Al_2O_3	4.77	7.07	4.67	
MgO	2.95	5.57	3.61	
FeO	60.65	56.59	64.07	
Fe_2O_3				80.98
MnO				4.09
Cr_2O_3	12.92	19.56	15.85	
Total	100.00	100.00	100.00	100.00
Cations				
Si		0.14	0.09	
Al	0.20	0.28	0.19	
Fe3	0.44	0.56	0.72	
Ti	0.47	0.18	0.24	
Cr	0.36	0.52	0.43	
Mg	0.15	0.28	0.19	
Fe2	1.35	1.04	1.14	
mg#(fe2)	0.10	0.21	0.14	
mg#(fe_tot)	0.08	0.15	0.09	
cr#(cr/(cr+al))	64.50	64.99	69.48	
Usp	0.82	0.55	0.52	

Oxides in wt%
Position: I - inclusion in olivine. G - groundmass
Name: sp - spinel. Ti-mt - titanomagnetite. Usp - ulvospinel

The iddingsitic rim of olivine and the lack of ilmenite phenocrysts of the Tekao type tholeiitic basalts are also a good confirmation and sign that our sample shows similarities to this type of tholeiitic basalt of Nuku Hiva (Legendre et al. 2005b). The only difference is that phlogopite occurs in our sample but there is no mention of it in the literature of tholeiitic basalts of Nuku Hiva. Phlogopite occurs only in benmoreite (Legendre et al 2005b), which is an intermediate type of this volcanic series, therefore the chemical composition of benmoreite strongly differs from the analysed flake.

Table 6.: Phlogopite compositional data of NUH-V1 basalt flake

6. táblázat: A NUH-V1 bazalt kőeszköz flogopitjának összetétele

Sample	NUH-V1	NUH-V1
Rock type	basalt	basalt
Position	G	G
Name	phlog	phlog
SiO_2	41.68	42.38
TiO_2	5.24	4.85
Al_2O_3	12.38	12.35
MgO	18.56	20.93
FeO*	10.27	7.31
K_2O	9.88	10.19
Total	98.00	98.00

Oxides in wt%
Position: G - groundmass
Name: phlog – phlogopite

Clinopyroxene composition of Tekao tholeiites (Mg-rich augite, Legendre et al. 2005b) are very close to which were analysed in NUH-V1 flake (**Fig. 13.**).

Legendre et al. (2005b) also mentioned Ca-poor pigeonite, whereas in the NUH-V1 flake we measured ferroan-enstatite which is very close to each other, almost within the analytical uncertainty of the analysing instrument. In conclusion we can confirm that the raw material of NUH-V1 basalt flake originates from the local Tekao type tholeiitic basalt mining site.

On the basis of the mineralogical and chemical composition, **NUH-H1** flake was made from **phonolite**. This rock type is quite rare in the Marquesas archipelago, and it cannot be found at all in Nuku Hiva. Only known occurrence in the archipelago is in Ua Pou, which island is located about 40 km south from Nuku Hiva. The main rock types of Ua Pou are phonolites, which are proved to be used to make stone tools (Bishop and Woolley 1973, Legendre et al. 2005a, McAlister and Allen 2017). The mineralogical component of the studied flake is almost the same as the C and D types of peralkaline phonolites described by Legendre et al. (2005a). The only differences are that in our flake analcime (which have formed from the alteration of nepheline) and a rare Zr and REE rich very fine grained mineral phase - which could be an eudialite-group mineral (probably a Ca-rich type sergevanite) - have been identified, which minerals have not been mentioned by Legendre et al. (2005a)).

Table 7.: Feldspathoid compositional data of NUH-H1 phonolite flake

7. táblázat: A NUH-H1 fonolit kőeszköz földpátpótlóinak összetétele

Sample	NUH-H1	NUH-H1	NUH-H1	NUH-H1	NUH-H1	NUH-H1	NUH-H1	NUH-H1	NUH-H1
Rock type	phonolite	phonolite	phonolite	phonolite	phonolite	phonolite	phonolite	phonolite	phonolite
Position	G	G	G	G	G	G	G	G	G
Name	nepheline	nepheline	nepheline	analcime	analcime	analcime	sodalite	sodalite	sodalite
SiO_2	48.18	46.46	46.78	55.49	55.77	57.16	38.71	39.36	39.97
Al_2O_3	34.33	32.29	32.26	26.41	26.07	26.72	32.24	31.60	32.45
FeO*	0.00	1.24	1.20	0.00	0.00	0.00	0.00	0.00	0.00
Na_2O	13.23	16.16	15.41	9.16	9.11	6.23	22.77	22.71	20.97
K_2O	4.25	3.85	4.34	0.93	1.05	1.89	0.00	0.00	
Cl	0.00	0.00	0.00	0.00	0.00	0.00	6.28	6.33	6.61
Total	100.00	100.00	100.00	92.00	92.00	92.00	100.00	100.00	100.00

Oxides in wt%
Position: G - groundmass

Table 8.: Compositional data of the eudialyte group mineral of NUH-H1 phonolite flake
8. táblázat: A NUH-H1 fonolit kőeszközben előforduló eudialit csoportba tartozó ásvány összetétele

Sample	**NUH-H1**	**NUH-H1**	**NUH-H1**	**NUH-H1**	**NUH-H1**	**NUH-H1**	**NUH-H1**	**NUH-H1**
Rock type	phonolite	phonolite	phonolite	phonolite	phonolite	phonolite	phonolite	phonolite
Position	G	G	G	G	G	G	G	G
Name	eudialyte*	eudialyte*	eudialyte*	eudialyte*	eudialyte*	eudialyte*	eudialyte*	eudialyte*
SiO_2	40.64	39.64	39.30	35.99	35.11	39.10	37.65	38.14
TiO_2	0.89	0.79	0.79	0.77	0.68	0.85	0.76	0.75
FeO*	4.28	4.04	3.87	3.74	3.54	4.10	3.58	3.87
MnO	2.38	2.89	2.97	2.07	2.52	2.27	2.23	2.77
CaO	31.44	33.15	33.04	27.31	28.82	30.06	33.47	31.70
Na_2O	9.77	9.34	9.18	8.94	8.53	9.50	8.58	9.08
ZrO_2	10.59	10.14	10.84	9.18	8.80	10.12	9.73	9.69
Total	100.00	100.00	100.00	88.00	88.00	96.00	96.00	96.00

Oxides in wt%
Position: G - groundmass
Remark: eudialyte* - eudialyte group mineral. probably Ca-rich sergevanite

The chemical composition even the major elements and the analysed trace elements and REE-s of the NUH-H1 flake is almost the same as the D type phonolite of Ua Pou (Legendre et al 2005a). Clinopyroxenes of the NUH-H1 flake (**Fig. 12.**) show a very close composition to which can be found in peralkaline phonolites of Ua Pou, mainly their C- and D-types (Legendre et al. 2005a). Also there is no knowledge of imported stone tools from other, farther archipelagos of the Pacific ocean until now (McAlister and Allen 2017). All this information confirms that the provenance of the studied phonolite flake is Ua Pou.

Conclusion

The investigated two artefacts are very similar in their macroscopic properties. At the same time, a detailed petroarchaeological analysis could find essential differences in the raw material and consequently in the potential source area as well. NUH-V1 was made of basalt while NUH-H1 was made of phonolite. The artefact made of basalt agrees well with the composition of the tholeiitic basalt occurring in the region of Vaitehii, within them, the so-called Tekao type basalt, that is, the flake originated from the local rock. Opposed to this, the object from Ha'anihani bay was made of phonolite, a rock type which does not occur on the island of Nuku Hiva. It is only known from an island about 40 km to the south of Nuku Hiva, namely Ua Pou where it crops out in significant quantities. According to the detailed petrographic and geochemical analyses, the composition of the phonolite artefact is very similar to that of the phonolite from Ua Pou, therefore we can conclude that it originated from there.

In conclusion we can confirm that the raw material of NUH-V1 flake have found in Vaitehhii I locality made from the local tholeiitic basalt mining site. On the contrary the flake have found in the Ha'anihani bay made from phonolite, and the provenance of this flake is Ua Pou.

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References

ANTONI, J. & FALCHETTO, A., (2021): Vaitehii: the cradle of the basalt adze-blades on Nuku Hiva, Marquesas Islands, *Archeometriai Műhely* **XVIII/1** 55–74. https://doi.org/10.55023/issn.1786-271X.2021-004

BENDŐ, ZS., SZAKMÁNY, GY., KASZTOVSZKY, ZS., T. BIRÓ, K., OLÁH, I., OSZTÁS, A., HARSÁNYI, I., SZILÁGYI, V. (2019): High pressure metaophiolite polished stone implements found in Hungary. *Archaeological and Anthropological Sciences* **11/5** 1643–1667; electronic version: https://doi.org/10.1007/s12520-018-0618-6,

BISHOP, A.C., WOOLLEY, A. R. (1973): A Basalt-Trachyte-Phonolite Series from Ua Pou, Marquesas Islands, Pacific Ocean. *Contributions to Mineralogy and Petrology* **39** 309–326.

BRADÁK, B., SZAKMÁNY, GY., JÓZSA, S., PŘICHYSTAL, A. (2009): Application of magnetic susceptibility on polished stone tools from Western Hungary and the Eastern part of Czech Republic (Central Europe). *Journal of Archaeological Science* **36** 2437–2444.

LEGENDRE, C., MAURY, R.C., CAROFF, M., GUILLOU, H. COTTENI, J. CHAUVEL, C. BOLLINGER, C., HÉMOND, C. GUILLE, G., BLAIS, S., ROSSI, P., SAVANIER, D. (2005a): Origin of Exceptionally Abundant Phonolites on Ua Pou Island (Marquesas, French Polynesia): Partial Melting of Basanites Followed by Crustal Contamination. *Journal of Petrology* **46/9** 1925–1962. https://doi.org/10.1093/petrology/egi043

LEGENDRE, C., MAURY, R.C., SAVANIER, D., COTTEN, J., CHAUVEL, C., HÉMOND, C., BOLLINGER, C., GUILLE, G., BLAIS, S., ROSSI, P. (2005b): The origin of intermediate and evolved lavas in the Marquesas archipelago: an example from Nuku Hiva island (French Polynesia). *Journal of Volcanology and Geothermal Research* **143** 293–317. https://doi.org/10.1016/j.jvolgeores.2004.12.001

McALISTER A, ALLEN MS (2017) Basalt geochemistry reveals high frequency of prehistoric tool exchange in low hierarchy Marquesas Islands (Polynesia). *PLoS ONE* **12/12 e0188207** 1–28: https://doi.org/10.1371/journal.pone.0188207

RÉVAY, Zs. (2009) Determining elemental composition using Prompt γ Activation Analysis *Analytical Chemistry* **81** 6851–6859.

SZAKMÁNY, GY., KASZTOVSZKY, ZS., SZILÁGYI, V., STARNINI, E., FRIEDEL, O., BIRÓ, K. T. (2011a): Discrimination of prehistoric polished stone tools from Hungary with nondestructive chemical Prompt Gamma Activation Analyses (PGAA). *European. Journal of Mineralogy* **23** 883–893.

SZAKMÁNY, GY., STARNINI, E., HORVÁTH, F. BRADÁK, B. (2011b): Investigating Trade and Exchange Patterns in Prehistory: Preliminary Results of the Archaeometric Analyses of Stone Artefacts from Tell Gorzsa (South-East Hungary). – in: TURBANTI-MEMMI, I (ed.): *Proceedings of the 37th International Symposium on Archaeometry*, 12th-16th May 2008, Siena, Italy, Springer-Verlag Berlin Heidelberg: 311–319.

SZENTMIKLÓSI, L., BELGYA, T., RÉVAY, Zs., KIS Z. (2010): Upgrade of the prompt gamma activation analysis and the neutron-induced prompt gamma spectroscopy facilities at the Budapest Research Reactor. *Journal of Radioanalytical and Nuclear Chemistry* **286** 501–505. http://dx.doi.org/10.1007/s10967-010-0765-4.

WILLIAMS-THORPE, O., THORPE, R.S. (1993). Magnetic susceptibility used in non-destructive provenancing of roman granite columns. *Archaeometry* **35/2** 185–195.