SOURCES OF CHERT FOR PREHISTORIC LITHIC INDUSTRIES IN MIDDLE DALMATIA

ADATOK KÖZÉP-DALMÁCIA ŐSKORI KŐESZKÖZEINEK NYERSANYAG-FORRÁSAIHOZ: KOVAKŐZETEK

ZLATKO PERHOČ

Email: zlatko.perhoc@web.de

Abstract

This contribution presents an overview of chert outcrops in Middle Dalmatia. It is a result of outcrop prospection and macroscopic analysis of cherts from the region, in the course of which a comparative collection of geological samples and a respective data base were formed. Middle Dalmatia is a part of the outer Dinaric Range, finally shaped by orogenesis during the Neogene, and acquiring recent maritime character since the end of Pleistocene. Lithologically, the region is built of carbonate rocks that were deposited continuously from Jurassic until Paleogene. Primary chert outcrops that appear within those rocks throughout the region are from Triassic, Jurassic, Cretaceous, and (most often) Paleogene, with secondary accumulations formed during the Quaternary Period. This overview presents results of the first phase of long-term research, aimed at correlating archaeological lithic inventories to regional sources of lithic raw material.

Kivonat

Ez a cikk áttekintést nyújt a közép-dalmáciai kova nyersanyagforrásokról. A munka személyes terepbejárások és makroszkópos vizsgálatok eredményeit rögzíti, melyek során létrejött egy összehasonlító gyűjtemény és az adatokat rögzítő adatbázis. Közép-Dalmácia a külső Dinaridák része, amely jelenlegi formáját a neogén hegységképző folyamatok során nyerte el. Mai, tengerközeli képe a pleisztocén végétől alakult ki. Litológiáját tekintve a területet karbonátos kőzetek építik fel, melyek a jura időszaktól a paleogén időszak végéig képződtek. Szingenetikus kovakőzetek a terület jelentős részén előfordulnak, a triász, jura, kréta és (leggyakrabban) a paleogén időszakból, míg másodlagosan képződött kovakőzetek a negyedidőszakban is képződtek. Ez az áttekintés egy hosszú távú kutatás első lépése, amelynek során a régészeti lelőhelyek kőeszközeit a terület nyersanyagforrásainak anyagához hasonlítjuk.

KEYWORDS: chert, Dalmatia, geoarchaeology

KULCSSZAVAK: kova, Dalmácia, geoarcheológia

Introduction

The aim of this contribution is to present the chert outcrops of Middle Dalmatia. The report is based on finds made in the course of geoarchaeological prospection of outcrops, macroscopic analyses of cherts from the outcrops. A comparative collection of chert samples from the region was formed in the course of prospection. This work represents an initial phase of a long-term geoarchaeological research, aimed at correlating lithic raw materials to lithic artifacts from the region. The ultimate aim of this research is to contribute to the reconstruction of lithic industry, one of the crucial elements of prehistoric economy in Dalmatia.

Until now, this kind of systematic research has not been carried out in Croatian archaeology in Middle Dalmatia. The issue of lithic raw material provenience was either skipped, or approached sporadically and in general terms. Relation between lithic finds and possible raw material sources was based on general geological information rather than focused research. The purpose of this paper is to expand our knowledge about cherts in Middle Dalmatia and to remove misconceptions about insufficient local chert sources. It should provide a sound base for rejection of the assumption about absence of such sources, and exclusively extra-regional acquisition of good quality chert raw materials required by local Dalmatian lithic industries (Robb and Farr 2005). It is limited to preliminary overview of chert outcrops, summary information about their location in Dalmatia, quantity of the chert, and evaluation of suitability of the outcrop to satisfy the needs of prehistoric flint knappers.

HU ISSN 1786-271X; urn: nbn: hu-4106

Fig. 1.: Topography of chert outcrops in Middle Dalmatia (Croatia). Outcrops are marked by numbers that correspond to numbers in text and tables

1. ábra: Kovakőzet nyersanyag lelőhelyek Közép-Dalmáciában. A térképen használt számok megegyeznek a szövegben használt hivatkozásokkal

The paper contains topography of each chert outcrop (**Figure 1**), and geology of the location (**Table 1**), a corresponding tabulation of basic information about outcrops selected for this occasion (**Table 2**). The description of each chert outcrop with elements of morphology has been presented in British Archaeological Report (Perhoč 2009).

The rock under discussion is chert, and its variety radiolarite. Based on the current insight into the archaeological collections from the region, those rocks are the best represented in Middle Dalmatian prehistoric lithic inventories since the beginning of Neolithic. The role that Middle Dalmatia plays in communication between the western and the eastern Adriatic shores (Radić 2003) influenced my choice of the research region, as did the connectedness of chert-bearing Dalmatia with chert-and-radiolarite-bearing Bosnia. Geomorphologic changes of the environment caused by the raising sea levels presented another challenge to this research.

The work of Milan Herak (1990) summarizes notions about frequency of chert occurrence in Dinaric Ranges and the wider geological region. Basic geological maps with their explanatory notes are the initial source of information about chert outcrops (Ivanović et al. 1978.; Karolija et al. 1977.; Magaš et al. 1979.; Marinčić et al. 1977.; Marinčić et al. 1973.; Papeš et al. 1984a.; Papeš et al. 1984b.), but they are not directly applicable to geological prospection.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

Table 1.: Chronostratigraphy of chert outcrops in Middle Dalmatia

Outcrop		Tri.	Jurassic			Cretaceous		Paleogene			Neogene		Quaternary	
		T_2	J_1	J_2	J_3	K_1	K_2	Pc	E	Ol	M	Pli	Ple	Ho
1	M. Palagruža, Medvidina													
2	Vela Palagruža, Pod Forane													
3	Sušac, Velo polje													
4	Lastovo Archipelago, Kopište													
5	Lastovo Archipelago, Mrčara													
6	Lastovo Isl., St. Mihovil C.													
7	Vela Luka, Moćni Laz													
8	Vela Luka, Lozica													
9	Vela Luka, Bradat Prid Bandon													
10	Vela Luka, Stračinčica													
11	Vela Luka, Kremenjača C.													
12	Vela Luka, Perna privale C.													
13	Vis Isl., Komiža, Barjaška C.													
14	Vis Town, Gradina													
15	Hvar Island, Katolić C.													
16	Brač, Pučišća, Mala Bračuta													
17	Brač, Dol													
18	Šolta, Grohote													
19	Čiovo, Saldun													
20	Primošten, Kremik													
21	Vilaja, Gradac													
22	Vilaja, Siništak													
23	Labinštica, Labinska Draga													
24	Labinštica													
25	Seget Gornji, Vlaška													
26	Seget Donji													
27	Resnik, Beach of Resnik													
28	Kozjak, Malačka													
29	Kozjak, Starosevski Gaj													
30	Kozjak, Matetina Peć													
31	Marjan													
32	Solin, Smiljanovac													
33	Mosor, Sitno													
34	Muć, Suvaja													
35	Muć, Visovac													
36	Cetina, Jare, Muša													
37	Svilaja, Lemeš													
38	Kamešnica, Poljane													
39	Biokovo, Baška Voda													
40	Biokovo, Makar													
41	Matokit, Vrgorac													
42	Neretva, Čeljevo													

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

Fig. 2.: Nodular chert from outcrops near Vela Luka on the island of Korčula

2. ábra: Velka Luka-i kovakőzet típusok

A field archaeologist in search of chert, equipped only with a geological map, must face numerous obstacles, the greatest of which is the huge difference between the size and visibility of a chert outcrop relative to the size of its host rock formation. Chert outcrops are not mapped individually on rock formations in which they occur, but are listed in explanatory notes next to the corresponding units. Wery helpful for this search was practical advice and instructions provided by the several old hands at Dalmatian geology, whom is hier to thank.

Methods

Primary tasks of the research program presented in this paper are: geoarchaeological field prospection, mapping of chert outcrops, documenting of outcrops and rocks at the outcrop, rock sampling, material analysis of lithic artifacts and geological samples, creation of a comparative collection of geological samples and petrographic types of lithic artifacts, as well as a corresponding data base.

Purpose of this research is to correlate geological lithics to lithic artifacts from Paleolithic and Neolithic sites within the region, using archaeometric methodology. The ultimate aim is to contribute to the reconstruction of prehistoric economy of Middle Dalmatia, from the aspect of lithic industry raw material provenance.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

Table 2.: Description of selected chert outcrops in Middle Dalmatia

Outcrop	1. Mala Palag., Medvidina	2. Vela Palagruža	3. Sušac, Velo Polje	5. Lastovo, Mrčara	7. Vela Luka, Moćni Laz	8. Vela Luka, Lozica
Chronostratigraphy	Uper Jurassic: Malm ; Quaternary	Uper Jurassic: Malm	Quaternary: Pleistocene	Uper Jurassic: Malm	Lower Creta.: Barremian-Albian	Upper Cretaceous: Turonian
Kind of rock	chert	chert	chert, radiolarite	chert	chert	chert
Coordinates*	42° 23´ 003´´ N 16° 16´ 003´´ E / 3 m	42° 23´ 537´´ N 16° 15´ 567´´ E / 66 m	42° 45´ 739´´ N 16° 29´ 949´´ E / 26 m	42° 46´ 269´´ N 16° 47´ 153´´ E / 2 m	42° 57´ 287´´ N 16° 42´ 801´´ E / 13 m	42° 58´ 697´´ N 16° 41´ 717´´ E / 95 m
Outcrop type	cliff, rockfall breccia, talus slope	cliff, debris deposit, talus slope	marine terrace / transgresive deposit	shore, beach	cut in hill slope	olive grove, vineyard
Outcrop size**	0,02 km	0,05 km	0,01 km^2		0,0004 km^2	1,2 km / 0,5 km^2
Rock form	nodules, pebbles, debris	nodules, rubble, pebbles, cobbles	pebbles, cobbles	thin layers, lenses, pebbles	lenses, thin layers	nodules, debris
Rock size	5-50 cm	5-50 cm	up to 7 cm	5-10 cm	up to 50 cm	5-20 cm
Outcrop usability	very high	high	medium	very low	low	medium
Outcrop	**9. Vela Luka, Bradat P. B.**	**10. Vela Luka, Stračinčica**	**11. Vela Luka, Kremenjača C.**	**12. Vela L., Perna privale C.**	**13. Komiža, Barjaška Cove**	**14. Vis, Gradina**
Chronostratigraphy	Upper Cretaceous: Turonian	Up. Creta.: Cenomanian, Turonian	Up. Creta.: Turonian; Quaternary	Up. Creta.: Turonian; Quaternary	Lower Cretaceous: Neocom	Quaternary: Pleistocene
Kind of rock	chert	chert	chert	chert	chert	chert
Coordinates*	42° 58´ 858´´ N 16° 41´ 554´´ E / 76 m	42° 58´ 813´´ N 16° 40´ 265´´ E / 30 m	42° 58´ 953´´ N 16° 37´ 075´´ E / 1 m	42° 59´ 009´´ N 16° 38´ 388´´ E / 1 m	43° 03´ 051´´ N 16° 03´ 320´´ E / 5 m	43° 07´ 389´´ N 16° 11´ 074´´ E / 18 m
Outcrop type	olive grove, hill slope	olive grove, hill slope	beach	beach	rocks on shore, beach	marine terrace / transgresive deposit
Outcrop size**	2,3 km / 0,1 km^2	0,005 km^2	0,02 km	0,04 km	0,1 km / 0,0001 km^2	1,5 km / 0,65 km^2
Rock form	nodules, lenses, debris	nodules, debris	pebbles, cobbles	pebbles, cobbles	nodules, lenses, pebbles	pebbles
Rock size	10-20 cm	5-25 cm	up to 100 cm	up to 10 cm	lenses up to 100 cm	up to 6 cm
Outcrop usability	medium, high	high, very high	medium	medium	medium	
Outcrop	**15. Hvar, Katolić Cove**	**16. Brač, Pučišća**	**17. Brač, Dol**	**19. Čiovo, Saldun**	**20. Primošten, Kremik**	**21. Vilaja, Gradac**
Chronostratigraphy	Upper Creta.: Cenomanian	Upper Creta.: Cenomanian	Upper Creta.: Cenomanian	Paleogene: Eocene; Quaternary	Paleogene: Eocene	Upper Cretaceous: Turonian
Kind of rock	chert	chert	chert	chert	chert	chert
Coordinates*	43° 09´ 479´´ N 16° 28´ 123´´ E / 9 m	43° 21´ 109´´ N 16° 44´ 019´´ E / 112 m	43° 20´ 657´´ N 16° 37´ 116´´ E / 93 m	43° 30´ 601´´ N 16° 15´ 311´´ E / 30 m	43° 34´ 247´´ N 15° 55´ 709´´ E	43° 36´ 541´´ N 16° 19´ 405´´ E / 255 m
Outcrop type	rocks on shore	rocks in hill slope	hill slope, talus slope	shore, hill slope, sinkholes	rocks in hill slope	road cut in hill slope
Outcrop size**	sporadic lenses	0,5 km^2	0,5 km^2	2,5 km / 0,73 km^2		1,5 km / 0,1 km^2
Rock form	lenses	lenses, debris	indented lenses, noduls, debris	nodules, lenses, debris	nodules, debris	lenses
Rock size	up to 10 cm	up to 10 cm	up to 15 cm	5-100 cm	up to 20 cm	50-100 cm
Outcrop usability	very low	low	low, medium	very high	medium	low, medium

Table 2.: Description of selected chert outcrops in Middle Dalmatia (continued)

Outcrop	1. Mala Palag., Medvidina	2. Vela Palagruža	3. Sušac, Velo Polje	5. Lastovo, Mrčara	7. Vela Luka, Moćni Laz	8. Vela Luka, Lozica
Chronostratigraphy	Uper Jurassic: Malm ; Quaternary	Uper Jurassic: Malm	Quaternary: Pleistocene	Uper Jurassic: Malm	Lower Creta.: Barremian-Albian	Upper Cretaceous: Turonian
Kind of rock	chert	chert	chert, radiolarite	chert	chert	chert
Coordinates*	42° 23´ 003´´ N 16° 16´ 003´´ E / 3 m	42° 23´ 537´´ N 16° 15´ 567´´ E / 66 m	42° 45´ 739´´ N 16° 29´ 949´´ E / 26 m	42° 46´ 269´´ N 16° 47´ 153´´ E / 2 m	42° 57´ 287´´ N 16° 42´ 801´´ E / 13 m	42° 58´ 697´´ N 16° 41´ 717´´ E / 95 m
Outcrop type	cliff, rockfall breccia, talus slope	cliff, debris deposit, talus slope	marine terrace / transgresive deposit	shore, beach	cut in hill slope	olive grove, vineyard
Outcrop size**	0,02 km	0,05 km	0,01 km^2		0,0004 km^2	1,2 km / 0,5 km^2
Rock form	nodules, pebbles, debris	nodules, rubble, pebbles, cobbles	pebbles, cobbles	thin layers, lenses, pebbles	lenses, thin layers	nodules, debris
Rock size	5-50 cm	5-50 cm	up to 7 cm	5-10 cm	up to 50 cm	5-20 cm
Outcrop usability	very high	high	medium	very low	low	medium

Outcrop	9. Vela Luka, Bradat P. B.	10. Vela Luka, Stračinčica	11. Vela Luka, Kremenjača C.	12. Vela L., Perna privale C.	13. Komiža, Barjaška Cove	14. Vis, Gradina
Chronostratigraphy	Upper Cretaceous: Turonian	Up. Creta.: Cenomanian, Turonian	Up. Creta.: Turonian; Quaternary	Up. Creta.: Turonian; Quaternary	Lower Cretaceous: Neocom	Quaternary: Pleistocene
Kind of rock	chert	chert	chert	chert	chert	chert
Coordinates*	42° 58´ 858´´ N 16° 41´ 554´´ E / 76 m	42° 58´ 813´´ N 16° 40´ 265´´ E / 30 m	42° 58´ 953´´ N 16° 37´ 075´´ E / 1 m	42° 59´ 009´´ N 16° 38´ 388´´ E / 1 m	43° 03´ 051´´ N 16° 03´ 320´´ E / 5 m	43° 07´ 389´´ N 16° 11´ 074´´ E / 18 m
Outcrop type	olive grove, hill slope	olive grove, hill slope	beach	beach	rocks on shore, beach	marine terrace / transgresive deposit
Outcrop size**	2,3 km / 0,1 km^2	0,005 km^2	0,02 km	0,04 km	0,1 km / 0,0001 km^2	1,5 km / 0,65 km^2
Rock form	nodules, lenses, debris	nodules, debris	pebbles, cobbles	pebbles, cobbles	nodules, lenses, pebbles	pebbles
Rock size	10-20 cm	5-25 cm	up to 100 cm	up to 10 cm	lenses up to 100 cm	up to 6 cm
Outcrop usability	medium, high	high, very high	medium	medium	medium	

Outcrop	15. Hvar, Katolić Cove	16. Brač, Pučišća	17. Brač, Dol	19. Čiovo, Saldun	20. Primošten, Kremik	21. Vilaja, Gradac
Chronostratigraphy	Upper Creta.: Cenomanian	Upper Creta.: Cenomanian	Upper Creta.: Cenomanian	Paleogene: Eocene; Quaternary	Paleogene: Eocene	Upper Cretaceous: Turonian
Kind of rock	chert	chert	chert	chert	chert	chert
Coordinates*	43° 09´ 479´´ N 16° 28´ 123´´ E / 9 m	43° 21´ 109´´ N 16° 44´ 019´´ E / 112 m	43° 20´ 657´´ N 16° 37´ 116´´ E / 93 m	43° 30´ 601´´ N 16° 15´ 311´´ E / 30 m	43° 34´ 247´´ N 15° 55´ 709´´ E	43° 36´ 541´´ N 16° 19´ 405´´ E / 255 m
Outcrop type	rocks on shore	rocks in hill slope	hill slope, talus slope	shore, hill slope, sinkholes	rocks in hill slope	road cut in hill slope
Outcrop size**	sporadic lenses	0,5 km^2	0,5 km^2	2,5 km / 0,73 km^2		1,5 km / 0,1 km^2
Rock form	lenses	lenses, debris	indented lenses, noduls, debris	nodules, lenses, debris	nodules, debris	lenses
Rock size	up to 10 cm	up to 10 cm	up to 15 cm	5-100 cm	up to 20 cm	50-100 cm
Outcrop usability	very low	low	low, medium	very high	medium	low, medium

The following Stone Age sites currently are included in the research program, in collaboration with their respective investigators (**Figure 1**): Mujina Cave near Labin Dalmatinski and Resnik (Mousterian), Kopačina Cave near Donji Humac on the island of Brač (Epigravettian and Mesolithic), Vela Cave in Vela Luka on the island of Korčula (Epigravettian, Mesolithic, Neolithic), as well as open air sites on the islands of Palagruža (Neolithic, Copper Age) and Sušac (Early Neolithic).

A set of archaeometric methods have been applied. Macroscopic analyses mainly have been related to fieldwork and cabinet work. The Application of microfacial methods of material investigation has been initiated using several laboratory techniques, primarily microscopic analysis of thin-sections under polarized light, and scanning electron microscope. Feasibility of prompt gamma activation analysis (a nondestructive technique of rock analysis) will be investigated as a continuance of a Hungarian – Croatian archaeometric bilateral collaboration project (2008-2009). Since the beginning of investigation in the fall of 2005 until the summer of 2009, numerous repeated prospections have been carried out at the mentioned locations within the region. Preparations included a study of topography and geology of the terrain, and collecting information about possible chert outcrops. This was augmented by study visits to chert deposits and prehistoric chert mines in Europe. Prospections consisted of field survey, aimed at locating primary and secondary chert outcrops. Aside from systematic collecting of rock samples, fieldwork included extensive and standardized documentation of outcrops. Cabinet work followed, consisting of processing of collected samples and data. A result of this work is a data base of chert raw materials and a sample collection of all regional rock varieties and types.

Chert deposits

In Middle Dalmatia, metasomatic nodular cherts appear in association with limestones and, less frequently, with dolomites, from Triassic to Paleogene. They are most common in Eocene flysch, while in Quaternary deposits they appear in loose sediments. The greatest concentration of cherts is located within the Eocene zone that stretches from Trogir to Drvenik, with a series of outcrops at Solin, Marjan, Mosor, Kozjak, Opor, Čiovo and at the base of Vlaška Mountain near Seget Donji (**Figure 1**). Due to their abundance, here one can talk about chert deposits. Elsewhere, chert outcrops represent "silica islands within a carbonate sea".

Fig. 3.: Rows of chert, Island of Mala Palagruža

3. ábra: Palagruža sziget a kovarétegek helyével

Small outcrops that stand out by their concentration of nodules and high quality of the rock are the Upper Cretaceous Stračinčica near Vela Luka (**Figure 2**) and the Jurassic Mala Palagruža (**Figure 3**).

The collection of samples from chert outcrops discussed in this work testifies clearly of the variability of types according to their geostratigraphic origin, but also of variability among outcrops of the same geological age, as well as the variability of types within a single outcrop. Since cherts of a common geochronology in Dalmatia are characterized by a certain degree of similarity, one or more common types can be defined that appear across several chronostratigraphically equivalent outcrops. Within the Jurassic group, Vela Palagruža and Mala Palagruža represent one pair of similar types, while Lastovo and Mrčara represent another such pair, to which one may add Svilaja-Lemeš type (Tišljar *et al.* 2002). Their common feature is a bedded, grainy structure, and light gray to yellowish gray color. Among the Cretaceous cherts one may distinguish between the types of dark brown, brown and reddish brown fine-grained, glossy stone, and the black, very fine-grained, glossy chert from outcrops at Vela Luka-Stratinčica, Kremenjača Cove, and Komiža-Barjaška Cove, as well as the grayish fine-grained chert from outcrops at Vela Luka-Bradat Prid Bandon, Lozice and Močni Laz, Brač-Pučišća and Dol, Labinščica, Seget Gornji-Vlaška, Vilaja-Sirištak and Gradac, Matokit-Vrgorac and Šolta-Grohote. Mutual similarity is the greatest among the Eocene cherts of the types Primošten-Kremik, Biokovo-Baška Voda, Čiovo (**Figure 4**), Marjan, Resnik, Labinska Draga, as well as the types Mosor-Sitno and Kozjak-Starosevski Gaj (**Figure 5**). A comprehensive data base of chert outcrops and types mentioned in this work will be published elsewhere.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

Fig. 4.: Limestone host rock with chert nodules, Saldun, Island of Čiovo

4. ábra: Čiovo-i kovakőzet feltárás

Fig. 5.: Chert nodules in rock of a road cut, Starosevski Gaj, Kozjak Mountain

5. ábra: Kozjak-Starosevski Gaj-i kovakőzet feltárás (útbevágásban)

Chert outcrops and their usability

Regarding the accessibility and usefulness of cherts within the region, over half of all the outcrops offer very good quality or medium quality raw materials, while a quarter of the outcrops are inferior. At primary outcrops, where nodules, indented lenses and thin layers of chert are embedded in host rock, partly loosened and easily accessible batches of chert and eroded clasts are always present in the immediate vicinity or adjacent talus slopes. Abraded chert nodules and clasts on the shore point to underwater primary deposits (Kremenjača and Perna privale Cove, 11-12; **Figure 2**) and notify of chert sources that were accessible to prehistoric stone collectors during periods with lower sea levels. Secondary accumulations of cherts, which are present at all primary outcrops – such as talus slopes, accumulations of debris (Matetina peć 30; **Figure 6**), beaches, alluvial accumulations of rivers and streams (e.g. Muć-Suvaja, 34; **Figure 7**), riverine terraces (Neretva River, 42), flysch (Solin, 32), or chert in sinkholes filled with *terra rossa* – represent easily accessible sources of raw material.

Fig. 6.: Fire access road cut section with eroded chert. Matetina Peć, Kozjak Mountain

6. ábra: Matetina -i kovakőzet feltárás

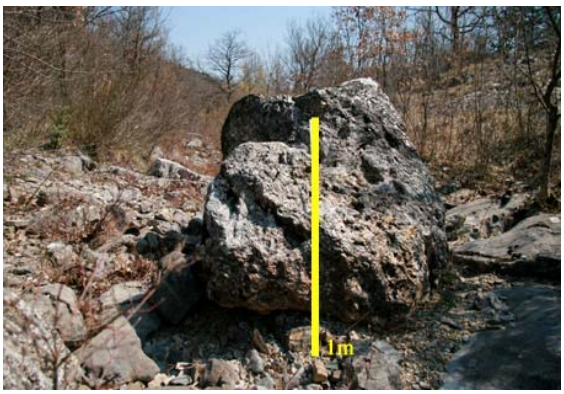

Fig. 7.: Block of chert, Muć-Suvaja

7. ábra: Kovatömb, Muć-Suvaja

Adriatic terraces with chert pebbles are a specific type of lithic raw material sources that were used in prehistory (Sušac, 3; **Figure 8** and Vis-Gradina, 14). Anthropogenic outcrops, i.e., excavations on construction sites, are nowadays helpful because they allow assessment of potential of chert deposits that used to be accessible in prehistory, but today are on cultivated land, inaccessible, or even unknown.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

Fig. 8.: Chert artifacts and chert pebbles. Velo Polje outcrop, Island of Sušac

8. ábra: Részben megmunkált kovakavicsok. Velo Polje, Sušac sziget

Quality of the stone was checked in the field by breakage. One should note that, aside from the undeniable quality of chert from fresh, resilient nodules, often it was possible to produce a reasonably good core out of nodules with relatively friable exterior. Even quite fractured and weathered fragments of eroded nodules may yield a solid core and homogenous flakes of desirable flatness and elongation, with smooth surfaces and sharp edges (e.g., Labinska Draga, 23). Markedly superior specimens may be found on outcrops dominated by mediocre chert (e.g., Dol on the island of Brač, 17). When one considers sources of relatively low quality stone, one should remember that the estimate of their potential usefulness in prehistory must take into account technological demands implied by the form of artifacts in question.

Despite over forty located and surveyed locations, comprehensiveness of this report may be questioned due to possible existence of unknown outcrops within the region. Experience that was gained during multiple prospecting of areas that presumably contained chert sources, unexpected finds of chert at places that were not located precisely by geological sources, or that were completely absent from them, and are unknown even to those familiar with the area, testify that all of the existing chert outcrops certainly have not been included in this study. The same experience warns us against premature conclusions about imported raw materials at archaeological sites with attested lithic artifact production where local cherts remain unknown. At the same time, given the connections between the opposite Adriatic coasts and the existence of chert mines in the Apennine Peninsula (Boschian 1995), chert raw material imports from the western to the eastern Adriatic coast cannot be ruled out.

For a number of reasons, an overview of all chert sources is not possible today, and their potential (abundance and accessibility) during prehistory is hard to assess. Among those reasons are redeposition of primary sources (Kozjak-Starosevski Gaj, 29; **Figure 5** and Kozjak-Matetina Peć, 30; **Figure 6**), redeposition of secondary sources (outcrops in olive groves and vineyards around Vela Luka), overgrown terrain (Sveti Duh formation on Brač), construction at an outcrop (Saldun on Čiovo, 19, **Figure 4**), or drowning of outcrops by the rising sea levels (Kremenjača Cove, 11 and Perna privale Cove, 12, near Vela Luka, **Figure 2**). There are hints of outcrops whose location remains unknown. On the island of Vis, in towns of Komiža and Vis, chert nodules were observed in masonry blocks used in construction; their structure may be related to a chert blade from a collection housed in the town of Vis. This find suggests that one should look for chert at the island's quarries. Geological information about Sveti Duh formation with Turonian and Upper Cretaceous limestones and dolomites, which contains lumps of chert in the area between Vidova Gora and Gornji Humac (Marinković 1984), as well as a secondary find of small debris of non-artifactual fossiliferous cherts at Trolokve (Forenbaher pers. comm. 2005), suggests that an unknown outcrop exists on Brač.

Possible ways of chert collection in Middle Dalmatia

The host rock to chert in Dalmatia is hard limestone. Extracting chert nodules, therefore, cannot be compared with extraction from chalkstone and marl deposits, which are the most common in Central and Northern Europe. For the time being, a mine like the one in Kleinkems in southern Germany, where chert was extracted from hard limestone after heat treatment of the rock (Fober and Weisgerber 1999), remains unknown in Dalmatia. Nevertheless, chert is fairly easily accessible. Given the nature of Dalmatian outcrops, one may presume that, during prehistory, it was collected in one of the following ways: by pick-up, by breaking and extracting the nodules from the host rock, and by digging. One can pick up eroded nodules and debris around many primary outcrops, chert debris on talus slopes near the bedrock (Dol on the island of Brač, 17), nodular pebbles and pebbles produced by rounding of chert debris during water transport at river shores and sandbanks (Neretva, 42), on Adriatic terraces (Sušac, 3; **Figure 8** and Vis, 14), on beaches next to talus slopes (Medvidina Cove at Mala Palagruža, 1; Saldun Bay at Čiovo, 19), and on beaches with underwater outcrops (Kremenjača Cove, and Perna privale Cove at Privala near Vela Luka, 11-12; **Figure 2** and Resnik, 27). Breaking off nodules that protrude from the host rock is possible if the overlying layers have been washed away. Extraction of complete nodules from the rock is

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

possible if mutual bonds between the layers have been weakened by weathering or tectonic disturbance, or where nodule beds have been washed out (Starosevski Gaj at Kozjak, 29; **Figure 5** and Čiovo, 19), or from weakly cemented breccias (Mala Palagruža and Vela Palagruža, 1-2; Marjan, 31). At Čiovo, Marjan, Matetina Peć on Kozjak, Sušac, and Biokovo-Baška Voda, it would have been possible to obtain chert in prehistory by excavation of simple pits (Fober and Weisgerber 1999). Since prehistoric stone knappers valued fresh chert that had not been exposed to weathering, and given the geological and morphological characteristics of Dalmatian outcrops, there is some justification to speculate that quarries and mines of the simplest kind would have existed.

Radiolarite pebble and chert pebble in archaeological lithic assemblages from Middle Dalmatian islands

Analysis of lithic raw materials from Epigravettian and Mesolithic assemblages from Kopačina Cave on the island of Brač and Vela Cave on the island of Korčula indicated that, aside from several types of chert, red radiolarite were used in production activity areas within those sites. Since primary deposits of radiolarite are absent from Middle Dalmatian islands and coast, the question arises about its origin, and the location of the secondary outcrop at which it had been collected. Radiolarite artifacts from Vela Cave and Kopačina Cave often preserve a well-rounded pebble weathering rind with percussion marks, typical indicators of transport of predominantly microcrystalline and cryptocrystalline quartz rock clasts by high-energy watercourse (Müller pers. comm. 2007). These pebbles of glaciofluvial origin (Roglić 1955) may have been transported by Neretva rivers, or they may be aggregats of gravels of similar origin, deposited on Adriatic terraces during Pleistocene transgressions (Malez 1979). Drežanka River takes in the chert and radiolarite components in the mountains of Čvrsnica and Čabulja, which constitute the upper part of its drainage basin, and introduces them into the Neretva River (Hrvatović i Papeš 2000).

If radiolarite (and chert *sensu stricto*) was collected from Neretva River (42) in prehistory, that may have been done in any part of its course where there are gravel aggregats along the shores, on sandbars, on riverine terraces, or in the delta. Together with Neretva gravels, radiolarite may have accumulated during the Quaternary along the recently formed island shores. Geomorphology of Neretva is dynamic, especially with regard to the location of its delta, due to the raising level of the Adriatic Sea during the Upper Pleistocene to Holocene transition (Šegota 1968). During the Last Glacial Maximum, the delta of Neretva was located in Korčula Channel, probably near the modern island of Šćedro next to Hvar, while the river was depositing huge amounts of gravel into the islandless Dalmatian Basin.

The northernmost outcrops of the Mesosoic deep-sea sediments with radiolarites in the eastern Adriatic appear on the mountain slopes of Montenegro, descend to the very coast, enter the sea and continue to the nearby islands (Goričan 1994). The origin of copious gravels with a high concentration of red radiolarite, nodular and bedded chert, found on the coast at Kamenari in Boka Kotorska, therefore is not in question. Prospection of Montenegrine coast was carried out just before this paper was completed. The upcoming laboratory analyses will either support or reject the notable macroscopic similarity of those materials with radiolarite artefacts from Vela Cave and Kopačina Cave. These finds might yet provide an important contribution to the study of the long-distance mobility of the people who inhabited the eastern Adriatic coast during prehistory.

It is not impossible that radiolarite and especial chert pebbles for lithic production on Korčula and Brač were collected at some Adriatic terrace. In the course of this research, one of those terraces, possibly a transgresive deposit of chert and radiolarite pebbles in *terra rossa* sediment, was discovered on the island of Sušac (3), and another one on the island of Vis (14). On Sušac, correlation with lithic artifacts from Early Neolithic sites indicates use of those pebbles *in situ* (**Figure 8**). On the surface of Velo Polje, a sizeable plateau covered by 60 centimeters of *terra rossa* sediment, pebbles of several types of chert, chert conglomerate, breccia, and radiolarite may be observed among numerous chert flakes, and occasional tools and obsidian flakes. Very small pebbles are included in the gravel, indicating that procurement of this raw material from some other source by the local stone knappers is out of the question. Sušac provides a well-documented example of lithic production at the very source of a raw material that is rare in Dalmatia. Similar pebbles have been reported from the island of Brač (Barbarić pers. comm. 2007), and from the island of Vis (Radić pers. com. 2007), presently without a clear archaeological context. A chert pebble with traces of processing, maybe of glaciofluvial or marine-abrasive origin, which we found at Divjeni doci near Sućuraj on the island of Hvar, among numerous surface finds of chert artifacts probably attributable to the Early Bronze Age (Vujnović 2002), testifies of *in situ* lithic production.

Conclusion

In Middle Dalmatia appears nodular chert of metasomatic origin. Cherts appear in Triassic, Jurassic, Cretaceous and Paleogene limestones.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

Chert outcrops, most of them not very extensive, are scattered throughout the region. The Eocene zone stands out by frequency and abundance of outcrops, especially within the Split-Kaštela Basin. All prehistoric lithic production activities within the region could have been supplied with chert raw material from the explored network of outcrops. Diversity of petrographic types in lithic artifacts, not all of which are present in local chert outcrops, suggests that raw material was procured from relatively wide regional surroundings. In a maritime environment, that implies navigation.

Acknowledgments

I am especially indebted to Prof. Dr Reiner Altherr, Institute of Earth Sciences, Heidelberg University, and Prof. Dr Josip Halamić, Croatian Geological Institute in Zagreb.

References

BOSCHIAN, G. 1995. The 'San Bartolomeo' shelter: a flint exploitation site in Central Italy. *Archaeologia Polona* **33**:31-40.

FOBER, L. and WEISGERBER, G. 1999. Feuersteinbergbau-Typen und Techniken. In G. Weisberger (ed.), *5000 Jahre Feuersteinbergbau: Die Suche nach dem Stahl der Steizeit* (3rd ed.). Bochum: Deutshes Bergbau-Museum, 32-47.

GORIČAN, S. 1994. Jurassic and Cretaceous radiolarian biostratigraphy and sedimentary evolution of the Budva Zone (Dinarides, Montenegro). *Mémoires de Géologie (Lausanne)* **18**:1-177.

HERAK, M. 1990. *Geologija* (5th ed.). Zagreb: Školska knjiga (textbook).

HRVATOVIĆ, H. and PAPEŠ, J. 2000. Adriatic-Dinaridic Carbonate Platform (External Dinarides). The River Neretva Canyon from Jablanica to Mostar. *Vijesti Hrvatskoga geološkoga društva* **37/2**: 81-83.

Hungarian – Croatian bilateral collaboration project 2008-2009. Archaeometrical research of lithic raw materials for Early Neolithic prehistoric communities with the help of Prompt gamma activation analysis, with special regard to radiolarites and obsidian. Available at: http://www.ace.hu/tet/english.html [Accessed 1. December 2008].

IVANOVIĆ, A., SIKIRICA, V., MARKOVIĆ, S. and SAKAČ, K. 1978a. *Osnovna geološka karta SFRJ, list Drniš, 1:100.000, K 33-9*. Zagreb: Institut za geološka istraživanja (1972). Beograd: Savezni geološki zavod. 1978b. *Osnovna geološka karta SFRJ, tumač za list Drniš, 1:100.000*. Zagreb: Institut za geološka istraživanja (1972). Beograd: Savezni geološki zavod.

KAROLIJA, B., BOROVIĆ, I., GRIMANI, I. and MARINČIĆ, S. 1977a. *Osnovna geološka karta SFRJ, list Korčula i Lastovo, 1:100.000, K 33-47, K 33-46.* Zagreb: Institut za geološka istraživanja. Beograd: Savezni geološki zavod.1977b. *Osnovna geološka karta SFRJ, tumač za list Korčula i Lastovo, 1:100.000.* Zagreb: Institut za geološka istraživanja. Beograd: Savezni geološki zavod.

MAGAŠ, N., MARINČIĆ, S. and BENČEK, D. 1979. *Osnovna geološka karta SFRJ, tumač za list Ploče, 1:100.000.* Zagreb: Institut za geološka istraživanja (1972). Beograd: Savezni geološki zavod.

MALEZ, M. 1979. Paleolitsko i mezolitsko doba u Hrvatskoj. Prirodni okviri. In Benac, A. (ed.), *Praistorija jugoslavenskih zemalja I. Paleolitsko i mezolitsko doba*, Sarajevo: Akademija nauka i umjetnosti Bosne i Hercegovine, Centar za balkanološka ispitivanja, 227-225.

MARINČIĆ S. KOROLIJA, B. and MAJCEN, Ž. 1977. *Osnovna geološka karta SFRJ, list Omiš, 1:100.000, K 33-22.* Zagreb: Institut za geološka istraživanja (1969). Beograd: Savezni geološki zavod.

MARINČIĆ, S., MAGAŠ, N. and BOROVIĆ, I. 1973a. *Osnovna geološka karta SFRJ, list Split i Primošten, 1:100.000, K 33-20, K 33-21.* Zagreb: Institut za geološka istraživanja (1967). Beograd: Savezni geološki zavod. 1973b. *Osnovna geološka karta SFRJ, tumač za list Split i Primošten, 1:100.000, K 33-20, K 33-21.* Zagreb: Institut za geološka istraživanja (1967). Beograd: Savezni geološki zavod.

MARINKOVIĆ, I. (ed.) 1984. *Prirodne osnove otoka Brača. Bračkizbornik 14*.

PAPEŠ J., MAGAŠ, N., MARINKOVIĆ, R., SIKIRICA, V. and RAIĆ, V. 1984a. *Osnovna geološka karta SFRJ, list Sinj, 1:100.000, K 33-10.* Zagreb: Institut za geološka istraživanja (1982). Beograd: Savezni geološki zavod.

PAPEŠ J., MAGAŠ N., SIKIRICA, V., and RAIĆ, V. 1984b. *Osnovna geološka karta SFRJ, tumač za list Sinj, 1:100.000.* Zagreb: Institut za geološka istraživanja (1982). Beograd: Savezni geološki zavod.

PERHOČ, Z. 2009. *Sources of Chert in Middle Dalmatia: Supplying Raw Material to Prehistoric Lithic Industries*. In S. Forenbaher (ed), *A Conectingg Sea: Maritime Interaction in Adriatic Prehistory*. Oxford: BAR International Series 2037, 25-46.

RADIĆ, D. 2003. Uloga doline Neretve i »otočnog mosta« u povezivanju istočne i zapadne jadranske obale. In E. Marin (ed.), *Arheološka istraživanja u Naroni i dolini Neretve*. Zagreb: Hrvatsko arheološko društvo, 305-320.

ROBB, J. E. and FARR, R. H. 2005. Substances in Moton: Neolithic Mediterranean 'Trade'. In E. Blake and B. Knapp (eds), *The Archaeology of Mediterranean Prehistory*. Oxford: Blachwell Publishing, 24-45.

ROGLIĆ, J. 1955. Geomorfološka istraživanja polja istočne Hercegovine u god. 1951. *Ljetopis Jugoslavenske akademije znanosti i umjetnosti* 60, 107-109.

ŠEGOTA, T. 1968. Morska razina u holocenu i mlađem djelu würma. *Geografski glasnik* 30, 16-39.

TIŠLJAR, J., VLAHOVIĆ, I., VELIĆ, I. and SOKAČ, B. 2002. Carbonate Platform Megafacies of the Jurassic and Cretaeous Deposits of the Karst Dinarides. *Geologica Croatica* 55(2), 139-170.

VUJNOVIĆ, N. 2002. Prethistorijsko i antičko razdoblje na području naselja Sućuraj. *Prilozi povijesti otoka Hvara* 11, 45-79.

HU ISSN 1786-271X; urn: nbn: hu-4106