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ARCHAEOMETRIC STUDY OF PROTOHISTORIC GRINDING TOOLS OF VOLCANIC ROCKS FOUND IN THE KARST (ITALY–SLOVENIA) AND ISTRIA (CROATIA)*

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This paper presents the results of the archaeometric study of 30 grinding tools found in the Karst plateau (an area that spreads from the northeastern border of Italy to Slovenia) and in the Istria peninsula (Croatia). The petrographic and geochemical characteristics of the artefacts indicate that most of them would be made of trachytic volcanites extracted from the Euganean Hills, near Padua (Veneto). It is known that trachytic rocks from this area had been widely exploited in northern Italy during protohistoric times, but these data considerably enlarge the area of diffusion of saddle-querns made of these rocks, extending it to Istria. Additionally, the likely provenance from Mount Etna of few other pieces of mugearites and hawaiites represents a new element, to be fully evaluated in the context of trans-Adriatic exchange/trade connections. Analytical data and possible archaeological inferences are presented in detail in the text.

KEYWORDS: PROTOHISTORIC AND ROMAN GRINDING TOOLS, KARST AND ISTRIA, TRACHYTES, HAWAIITES AND MUGEARITES

INTRODUCTION

Grinding tools represent a class of materials of wide geographical distribution and long diachronic presence, accompanied by relatively few morphological changes through time. Nevertheless, a general distinction between manual grinding tools and rotary querns is possible, and it would reflect a chronological difference, rotary querns having appeared and spread rapidly only in the Roman period (Thorpe-Williams 1988; Kardulias and Runnels 1995).

As for manual grinding tools, numerous technomorphological studies, often based on ethnographic data and use wear analyses, have produced typologies that, in spite of some differences, recognize saddle-querns as one of the basic forms. Saddle-querns are composed of two stones: an active implement—usually called a handstone—worked with a linear movement of the hand(s) on a passive surface—a grinding slab or grindstone (Curwen 1937; Storck and Teague 1952; Roux 1986; De Beaune 1989). This class of artefacts can also be studied from a different viewpoint, through archaeometric analyses aimed at determining the source of provenance of the rocks used to manufacture them, and on this basis recognizing possible ancient exchange

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and trade networks (see, e.g., Peacock 1980, 1986, 1989; Ferla *et al.* 1984; Thorpe-Williams 1988; Thorpe-Williams and Thorpe 1988, 1990, 1993). Such studies have been carried out in recent years in different regions of Italy (see, e.g., Cattani *et al.* 1997; Antonelli *et al.* 2000, 2001; Capedri *et al.* 2000; Lorenzoni *et al.* 2000a,b), but only a few materials of Roman age from Friuli Venezia Giulia and the adjacent territories have been analysed so far (Lazzarini and Župančíć, pers. comms).

MATERIALS AND METHODS

The archaeometric approach has been chosen to study a sample of 30 ground stone tools made of volcanic rocks from eight protohistoric sites, four located in the Trieste Karst (northeastern Italy), one in inner Slovenia and three in Istria (Croatia) (Fig. 1).

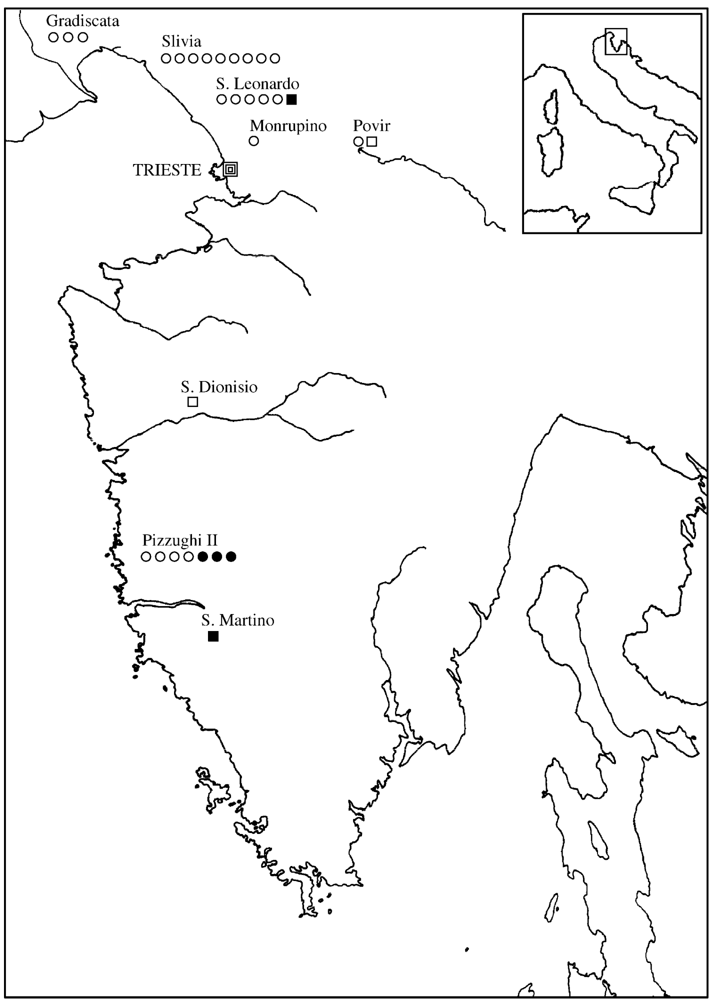

Figure 1 *The distribution of the grinding tools and their petrographic origin.* ●*, Euganean trachytes from Mt Rosso;* ○*, Euganean trachytes from Mt Altore-Rocca Pendice;* ■*, Etnean hawaiites;* □*, Etnean mugearites.*

All of the sites are *castellieri*—that is, settlements enclosed by dry-stone walls—built on hilltops from the Middle Bronze Age to the Late Iron Age, but often also reused in historical times. The c*astellieri* were first identified and surveyed in the last decades of the 19th century (Marchesetti 1903), but systematic investigations have only been carried out since the second half of the 20th century, and only at a limited number of sites (*Preistoria del Caput Adriae* 1983; Karoušková-Soper 1984; *Il civico museo archeologico di Muggia* 1997; *Carlo Marchesetti e i castellieri—1903–2003* 2003).

Unfortunately, the ground stone tools examined in the present study do not come from stratified deposits, but from surface collections (Marchesetti 1903; Bernardini 2002): their chronological attribution is consequently rather uncertain, as the whole period of use of the site of provenance, including isolated episodes of occupation in historical times, must be taken into consideration.

From the morphological viewpoint, all of the pieces would belong to saddle-querns, with the exception of three rotary querns (in one case—CP5—the attribution of the fragment to a rotary quern is based mainly on lithological grounds; affinity with the other samples). The bad state of preservation of most saddle-querns, which have often been reduced to very small fragments, prevents us from proposing any typological scheme; however, handstones can be distinguished from grinding slabs in few cases (the latter apparently show either an oval, elongated shape—CSL2, which is comparable with type A of the typology proposed by Cattani *et al.* (1997)—or an irregular, rectangular one—CG3 and CP1). A generic attribution to the category is nonetheless more frequent (see Table 1 and Fig. 2), and even this is sometimes uncertain.

The petrographic features of the grinding tools are reported in Table 2, whereas the major and some trace elements (Rb, Sr, Y, Zr, Nb, V, Pb, Th, Hf and REE) of 22 of them, determined at the *Activation Laboratories LTD* (ACLTABS) of Ancaster (Ontario, Canada) by inductively coupled plasma–mass spectrometry (ICP–MS), are listed in Table 3. The precision and accuracy of the chemical element determinations have been reported by Capedri *et al.* (2002).

PETROGRAPHIC AND GEOCHEMICAL RESULTS

Most analysed stones are intermediate lavas (SiO_2 52–66 wt%) which, according to the usual schemes of classification (Le Maitre *et al.* 1989; Fig. 3), are classified into two different groups: (i) transitional trachytes and (ii) basic lavas (SiO_2 < 45 wt%)—two hawaiites (CSL6 and CSM1) and two mugearites (CSD1 and CP02) (Fig. 3):

(i) The *trachytes* used for protohistoric grinding tools (Table 3) share similar petrographic features: they are grey-brown to brown-reddish, mildly vesiculated and porphyritic (P.I. 5–20, usually 6–10) with phenocrysts of euhedral plagioclase, anhedral to subhedral anorthoclase and skeletal biotite (Fig. 4 (a)), besides zircon and apatite as accessories, in a *hyalopilitic* matrix. The latter is composed of microlites of sanidine–plagioclase–opaques ± interstitial quartz and minute interstitial brownish glass (in order of decreasing abundance). On the contrary, Roman rotary querns CP5, CP6 and CP7 (Table 2) are greyish, more strongly porphyritic (P.I. 22–28) and slightly seriate in texture, with phenocrysts composed mainly of euhedral to subeuhedral plagioclase and anorthoclase, besides more rare biotite and clinopyroxene as phenocrysts; zircon, apatite and opaques are primary accessories, whereas chlorite is an alteration product. These same phases, plus or minus interstitial accessory quartz, compose the felsitic groundmass.

(ii) The *basic lavas* (hawaiites CSL6 and CSM1, mugearites CSD1 and CP02; see Tables 2 and 3) are petrographically very similar. They are greyish in colour, slightly vesicular and porphyritic

Table 1 *Typology of the grinding tools*

Archaeological site	*Sample*	*Typology*	*Length (cm)*	*Width (cm)*	*Thickness (cm)*	*Weight (g)*
Castelliere Gradiscata, Gorizia, Italy	CG 1	Saddle-quern, handstone	12	10.5	6.4	870
	CG 2	Saddle-quern, handstone	11.3	7.5	3.3	300
	CG 3	Saddle-quern, grinding slab	14	8	7.5	1440
Castelliere Slivia, Trieste, Italy	CS1	Saddle-quern	10.6	7.5	4.4	560
	CS2	Saddle-quern, grinding slab	13.5	9	4.7	600
	CS3	Saddle-quern	9	9	2.5	270
	CS4	Saddle-quern	6.5	3.3	2.8	130
	CS5	Undetermined	2.5	2	–	10
	CS6	Undetermined	3.6	3	–	23
	CS7	Undetermined	3	2.5	–	10
	CS8	Undetermined	11	8.2	–	650
	CS9	Undetermined	2.5	2.2	–	10
Castelliere S. Leonardo, Trieste, Italy	CSL1	Saddle-quern	7	6	5.6	200
	CSL2	Saddle-quern, grinding slab	15	14	5.6	1400
	CSL3	Saddle-quern, handstone	12.3	9	8.3	1030
	CSL4	Saddle-quern	7.4	3.5	2.4	115
	CSL5	Undetermined	3	2.7	–	15
	CSL6	Saddle-quern?	15	8.5	4.8	930
Castelliere Monrupino, Trieste, Italy	CM1	Saddle-quern	11	4	4.5	265
Castelliere Povir, Slovenia	CPO1	Saddle-quern, grinding slab?	8	5.5	4.5	200
	CPO2	Undetermined	7	5.5	–	160
Castelliere S. Dionisio, Croatia	CSD1	Saddle-quern?	5.5	5	4.7	130
Castelliere Pizzughi II, Croatia	CP1	Saddle-quern, grinding slab	12	8.6	6	860
	CP2	Saddle-quern?	6.5	6.5	3.3	130
	CP3	Saddle-quern?	5	4.8	3	140
	CP4	Saddle-quern	6	3.5	3.5	100
	CP5	Rotary quern	7	6	2.5	150
	CP6	Rotary quern, fragment of upper stone	11	9.5	9	1050
	CP7	Rotary quern, fragment of upper stone	16	10	10	2050
Castelliere S. Martino, Croatia	CSM1	Saddle-quern?	5.5	4	6	220

(P.I. 30–40 in hawaiites, 15–25 in mugearites). Phenocrysts—composed of euhedral labradoritic–bytownitic plagioclase (An 65–75%; optical determination), euhedral–subhedral light green clinopyroxene, euhedral olivine altered into iddingsite and opaques minerals—are in an intergranular groundmass made of the same minerals, besides K-feldspar (in mugearites).

PROVENANCE

Petrographically, the protohistoric and Roman trachytic grinding tools are comparable—as to modal composition, texture, K_2O/Na_2O ratio and presence of Q and Hy in the CIPW norm (Tables 2 and 3 and Milani *et al*. 1999)—to the Na-trachytes of the Euganean Hills, a Tertiary volcanic

Table 2 *Petrographic features of the grinding tools*

	Archaeological site							
	Castelliere Slivia, Trieste	*Castelliere Monrupino, Trieste*	*Castelliere Gradiscata, Gorizia*	*Castelliere S. Leonardo, Gorizia*	*Castelliere Povir, Slovenia*	*Castelliere S. Dionisio, Croatia*	*Castelliere Pizzughi II, Croatia*	*Castelliere S. Martino, Croatia*
Sample reference: • Protohistoric • Roman	CS1–CS9	CM1	CG1–CG3	CSL1–CSL6	CPO1 and CPO2	CSD1	• CP1–CP4 • CP5–CP7	CSM1
Grinding tools typology	Saddle-querns	Saddle-quern	Saddle-querns	Saddle-querns	Saddle-querns	Saddle-quern	• Saddle-querns • Rotary querns	Saddle-quern
Rock type	Trachyte	Trachyte	Trachyte	CSL1–CSL5: trachyte CSL6: hawaiite	CPO1: trachyte CPO2: mugearite	Mugearite	Trachyte	Hawaiite
Porphyric index	10–18%	~ 10%	5–7%	CSL1–CSL5: 6–8% CSL6: ~ 40%	CPO1: ~ 18% CPO2: ~ 15%	~ 14%	CP1–CP4: 10–15% CP5–CP7: 22–28%	~ 35%
Phenocryst mineralogy	ancl ≥ pl > biot ± ore min.	pl > ancl > biot	pl > ancl ≥ biot ± ore min.	CSL1–CSL5: pl ≥ ancl + biot CSL6: pl > cpx > ol	CPO1: pl > ancl > biot CPO2: pl > cpx ± ol	pl > cpx ± ol	CP1–CP4: pl ≥ ancl > biot CP5–CP7: pl > ancl ≥ biot > cpx ± chl	pl > cpx ≥ ol + ore min
Groundmass texture	Pilotassitic–hyalopilitic (coarse micro.)	Pilotassitic–hyalopilitic (coarse micro.)	Pilotassitic–hyalopilitic (coarse micro.)	CSL1–CSL5: pilotassitic (coarse micro.) CSL6: intergranular (microcrystalline)	CPO1: pilotassitic (coarse micro.) CPO2: intergranular (microcrystalline)	Intergranular (microcrystalline)	CP1–CP4: pilotassitic (coarse micro.) CP5–CP7: felsitic (microcrystalline)	Intergranular (microcrystalline)
K_2O/Na_2O	0.80–0.98	0.98	0.99–1.01	CSL1–CSL5: 0.96–0.98 CSL6: 0.45	CPO1: 0.93 CPO2: 0.49	0.50	CP1–CP4: 0.95–0.97 CP5–CP7: 1.02–1.09	0.50
Probable provenance	Euganean Hills, Italy (VMP)	Euganean Hills, Italy (VMP)	Euganean Hills, Italy (VMP)	CSL1–CSL5: Euganean Hills, Italy (VMP) CSL6: Etna, Sicily, Italy	CPO1: Euganean Hills, Italy (VMP) CPO2: Etna, Sicily, Italy	Etna, Sicily, Italy	Euganean Hills, Italy (VMP)	Etna, Sicily, Italy

Abbreviations: pl, plagioclase; cpx, clinopyroxene; ancl, anorthoclase; san, sanidine; biot, biotite; cl, chlorite; ol, olivine; ore min., ore minerals; coarse micro., coarse microcrystalline. VMP, Venetian Magmatic Province.

Table 3 *The major and trace elements and normative compositions (C.I.P.W.) of the studied millstones*

Sample	*Slivia*						*Gradiscata*		*Pizzughi II*					*San Leonardo*				*Povir*		*San Dionisio*	*San Martino*	*Monrupino*
	CS1 (T)	*CS2 (T)*	*CS3 (T)*	*CS4 (T)*	*CS7 (T)*	*CS8 (T)*	*CG1 (T)*	*CG3 (T)*	*CP1 (T)*	*CP3 (T)*	*CP5 (T)*	*CP6 (T)*	*CP7 (T)*	*CSL1 (T)*	*CSL3 (T)*	*CSL5 (T)*	*CSL6 (H)*	*CP01 (T)*	*CP02 (M)*	*CSD1 (M)*	*CSM1 (H)*	*CM1 (T)*
Oxides (%)																						
SiO_2	64.7	65.4	59.6	59.1	64.1	65.0	65.4	65.1	65.4	64.4	64.0	64.7	63.8	64.7	65.4	65.0	48.8	64.5	51.0	51.2	48.9	63.5
TiO_2	0.68	0.59	1.06	1.07	0.66	0.68	0.60	0.67	0.64	0.67	1.00	0.96	0.99	0.64	0.63	0.65	1.68	0.66	1.66	1.74	1.65	0.67
Al_2O_3	17.0	16.2	17.3	16.9	16.4	16.8	16.3	16.9	16.5	16.2	15.9	15.7	15.5	16.7	16.6	16.4	16.3	16.6	18.3	17.5	17.0	16.8
Fe_2O_3	3.31	3.09	4.63	4.71	3.22	3.58	3.04	3.33	3.05	3.36	4.30	4.35	4.42	3.21	3.17	3.03	11.1	3.15	9.82	9.67	10.8	4.01
MnO	0.05	0.05	0.07	0.07	0.05	0.05	0.05	0.07	0.05	0.07	0.07	0.05	0.06	0.05	0.05	0.05	0.17	0.06	0.16	0.18	0.17	0.05
MgO	0.61	0.61	1.33	1.43	0.67	0.81	0.52	0.58	0.48	0.67	0.77	1.06	1.10	0.61	0.57	0.45	5.55	0.48	3.24	3.19	4.95	0.72
CaO	1.44	1.69	2.95	4.23	1.38	1.32	1.58	1.32	1.96	1.73	2.82	3.01	2.91	1.41	1.40	1.29	9.92	1.40	8.86	8.24	9.74	1.25
Na_2O	5.45	5.28	5.49	5.30	5.47	5.34	5.32	5.51	5.23	5.41	4.55	4.20	4.21	5.43	5.24	5.37	3.79	5.57	4.20	4.43	3.89	5.17
K_2O	5.13	5.16	4.38	4.45	5.19	5.17	5.36	5.45	5.08	5.16	4.62	4.54	4.60	5.28	5.14	5.17	1.70	5.17	2.06	2.22	1.93	5.06
P_2O_5	0.31	0.28	0.56	0.58	0.26	0.32	0.27	0.31	0.60	0.50	0.49	0.42	0.48	0.32	0.26	0.30	1.68	0.27	0.77	0.81	0.67	0.24
LOI	1.39	1.17	2.34	1.89	1.41	1.22	1.51	1.00	1.06	1.05	1.19	1.09	1.48	1.21	1.41	1.11	0.10	1.21	0.19	0.18	0.15	2.66
K_2O/Na_2O	0.94	0.98	0.80	0.84	0.95	0.97	1.01	0.99	0.97	0.95	1.02	1.08	1.09	0.97	0.98	0.96	0.45	0.93	0.49	0.50	0.50	0.98
ppm																						
Rb	125	132	109	106	133	127	130	127	129	130	141	135	144	137	123	135	35	124	39	46	35	127
Sr	211	227	688	641	211	212	176	227	261	232	502	517	416	202	208	210	1400	234	1470	1390	1430	202
Ni	22	Nd	Nd	22	nd	nd	Nd	nd	nd	nd	nd	23	Nd	nd	20	21	58	Nd	29	313	49	nd
Y	28	31	36	32	31	27	32	31	32	28	31	32	30	38	31	32	28	29	30	34	27	30
Zr	908	753	592	571	954	769	922	991	740	924	459	435	443	978	739	969	204	742	232	267	196	738
Nb	229	94	89	87	104	94	102	103	93	100	70	65	67	108	90	103	56	94	68	77	57	93
V	13	10	32	29	13	9	13	15	11	15	54	44	42	14	10	13	261	10	191	195	242	11
Pb	14	15	12	12	19	11	30	12	11	16	11	11	13	14	11	10	18	16	10	9	11	16
Th	15	16	12	12	15	16	16	16	16	15	14	14	15	16	16	16	12	16	14	16	12	16
Hf	16	18	13	13	17	18	17	18	18	17	11	11	11	17	18	18	5	18	6	7	5	18
La	128	81	104	91	125	84	93	85	106	80	65	62	66	160	131	102	75	91	87	98	75	75
Ce	136	139	150	144	138	122	136	141	150	132	120	116	116	156	128	138	141	128	159	180	139	111
Pr	22	15	19	17	21	16	18	16	20	15	13	13	14	30	24	19	16	17	18	21	16	15
Nd	69	51	67	59	68	53	60	54	65	50	47	47	48	97	76	62	59	57	63	73	57	51
Sm	11	9	11	10	11	9	10	9	11	8	9	9	9	15	12	10	10	10	11	12	10	9

Eu	2.9	2.5	3.4	3.2	2.9	2.6	2.7	2.7	3.0	2.5	2.6	2.6	2.6	3.7	3.3	2.8	3.2	2.7	3.2	3.6	3.1	2.7
Gd	9.0	7.2	10.0	8.8	9.3	6.8	8.6	7.6	8.6	6.9	7.5	7.3	7.4	12.7	10.0	8.4	8.1	7.8	8.4	9.6	7.8	7.2
Tb	1.2	1.1	1.4	1.2	1.3	1.0	1.3	1.1	1.3	1.0	1.1	1.1	1.2	1.6	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1
Dy	5.7	5.9	6.8	6.2	6.3	5.3	6.3	6.0	6.4	5.4	5.9	6.1	6.0	7.8	6.6	6.2	5.7	6.0	5.9	6.8	5.5	5.8
Ho	1.0	1.1	1.3	1.1	1.1	1.0	1.2	1.1	1.1	1.0	1.1	1.1	1.1	1.4	1.2	1.2	1.0	1.1	1.1	1.3	1.0	1.1
Er	2.7	2.9	3.1	2.9	2.9	2.6	2.9	2.9	3.0	2.7	2.9	3.0	2.9	3.4	3.0	3.0	2.7	2.8	2.9	3.3	2.6	2.9
Tm	0.36	0.42	0.41	0.38	0.39	0.36	0.42	0.40	0.42	0.38	0.41	0.41	0.41	0.46	0.41	0.41	0.36	0.38	0.38	0.43	0.34	0.42
Yb	2.3	2.7	2.5	2.4	2.6	2.4	2.6	2.6	2.6	2.4	2.6	2.6	2.5	2.9	2.6	2.6	2.2	2.5	2.4	2.8	2.2	2.7
Lu	0.33	0.38	0.34	0.33	0.36	0.35	0.37	0.37	0.37	0.34	0.36	0.38	0.36	0.40	0.37	0.37	0.32	0.37	0.35	0.40	0.31	0.39
C.I.P.W. norm																						
Qz	8.67	9.97	2.34	1.24	7.72	0.27	9.35	7.76	10.97	8.39	12.3	14.38	13.27	8.33	10.6	9.96		7.89				9.36
C	0.61					0.79		0.28						0.26		0.34						0.55
Or	30.3	30.5	25.9	26.3	30.68	30.56	31.68	32.21	30.03	30.5	27.31	26.83	27.19	31.31	30.38	30.56	10.05	30.56	12.18	13.12	11.41	29.91
Ab	46.1	44.67	46.5	44.84	46.28	45.18	45.01	46.62	44.25	45.77	38.5	35.54	35.62	45.94	44.34	45.42	28.64	47.13	32.22	33.81	23.44	43.74
An	5.12	5.27	9.63	9.19	4.87	4.46	4.77	4.52	5.8	4.68	9.32	10.58	9.81	4.9	5.25	4.44	22.45	5.03	25	21.31	23.23	6.2
Ne																	1.86		1.8	1.99	5.13	
Di		1.09	1.13	6.69	0.23		1.11			0.54	1.25	1.35	1.25				12.03	0.13	11.64	11.93	17.14	
Hy	4.98	4.28	7.41	4.97	4.92	5.85	3.96	4.99	4.37	4.98	5.6	6.37	6.59	4.91	4.78	4.25		4.43				4.43
Ol																			9.74	9.32	11.85	
Mt	0.6	0.5	0.8	0.8	0.6	0.6	0.52	0.57	0.53	0.5	0.7	0.8	0.79	0.6	0.6	0.52	1.01	0.54	1.69	1.7	1.9	0.69
Ilm	1.29	1.12	2.01	2.03	1.25	1.29	1.14	1.27	1.22	1.27	1.9	1.82	1.9	1.22	1.2	1.13	3.19	1.25	3.15	3.3	3.13	1.27
Ap	0.73	0.66	1.33	1.37	0.62	0.76	0.6	0.7	1.4	1.18	1.16	0.99	1.14	0.76	0.6	0.71	3.98	0.64	1.82	1.92	1.6	

Abbreviations: T, trachyte; M, mugearite; H, hawaiite.

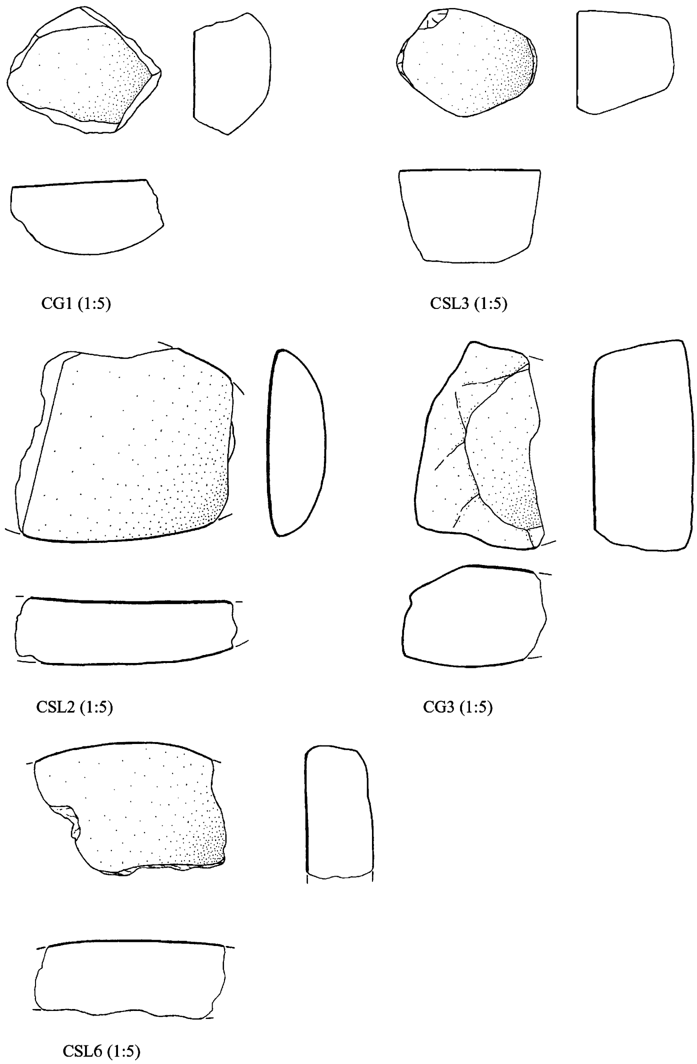

Figure 2 *Some of the grinding tools examined in this study: CG1 and CSL3, handstones; CSL2 and CG3, grinding slabs; CSL6, fragment of a grinding slab(?). All of the artefacts are made of trachyte, with the exception of CSL6, which is made of hawaiite (drawings by M. Mondo).*

complex close to Padua in northern Italy. More precisely, they have much in common with the petrography of the trachytes from the Monte Murale and Monte Rosso quarries, respectively (Capedri *et al*. 2000). The similarity with the Euganean rocks is strengthened by the distribution and profiles of both incompatible and rare earth elements of most archaeological samples (Fig. 5 (a)). Four items (CSL1, CSL3, CS1 and CS7), however, have light REE concentrations that are higher than those of the Euganean trachytes (Fig. 5 (b)) and show a negative Ce anomaly. This feature implies the fractionation, at variable proportions, of one mineral phase concentrating Ce in respect of La; allanite—which is commonly enriched in Ce—has been reported in some Euganean trachytes where a negative Ce anomaly has also been documented

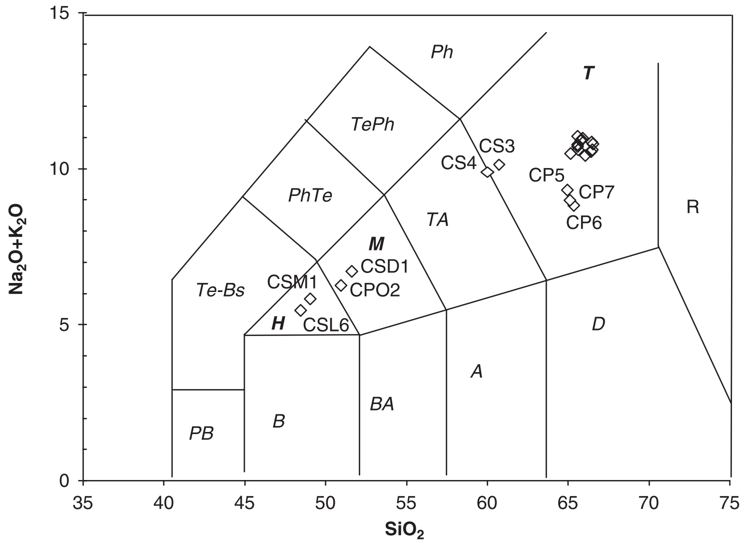

Figure 3 *An alkali-silica classification diagram (Le Maitre* et al. *1989). H, hawaiites; M, mugearites; TA, trachy-andesites; T, trachytes; PB, picro-basalts; B, basalts; BA, basaltic andesites; A, andesites; D, dacites; Te-Bs, tephrites and basanites; PhTe, phono-tephrites; TePh, tephri-phonolites; Ph, phonolites; R, rhyolites. Values recalculated to 100% on an H_2O- and CO_2-free basis.*

(Capedri *et al.* 2000 and unpublished data). As a matter of fact, the Euganean Hills are the only possible geological source for the trachytes used to manufacture the ground stone tools analysed in this study: in Italy, trachytes actually occur in two other localities, Monte Amiata in Tuscany (Giraud *et al.* 1986 and references cited therein) and Monte Arci in Sardinia (Montanini 1992), but those rocks are very different, both petrographically and chemically, from the present archaeological samples.

Within the Euganean provenance, we can try to identify the sites exploited for the production of grinding tools pertaining to that volcanic complex using diagrams proposed for the discrimination of the Euganean quarries (Capedri *et al.* 2000). As shown in Figure 6 (a), which relates Th to Sr, protohistoric saddle-querns fall into *field 3*, which is defined by the Monte Altore and Rocca Pendice rocks. Only samples CS3 and CS4 fall far outside the fields defined by the Euganean trachytes; as a matter of fact, they compare chemically, particularly in their Sr concentrations, to the alkaline trachyandesites (latites) of that magmatic complex (Milani *et al.* 1999). Therefore, their provenance cannot be inferred using the diagrams of Figure 6. Since Monte Altore could be accessed and exploited from the plain more easily than Rocca Pendice, which is quite some way inland, we might consider this area as the most probable source for all of the present protohistoric trachytic materials. Nevertheless, on the basis of the chemical data, these areas that are connected to the above localities partly contradict the petrographic results, and may be confirmed only by additional investigations on a larger number of reference samples. Conversely, in Figure 6 (a) the three Roman rotary querns fall into *field 4*, which is defined by trachytes from various localities (Capedri *et al.* 2000), including Monte Rosso. The provenance from Monte Rosso, which was among the most important Euganean quarries in Roman times (Zantedeschi and Zanco 1993; Renzulli *et al.* 1999), is suggested by the petrography and strengthened by the Zr/TiO_2 ratios (Fig. 6 (b)).

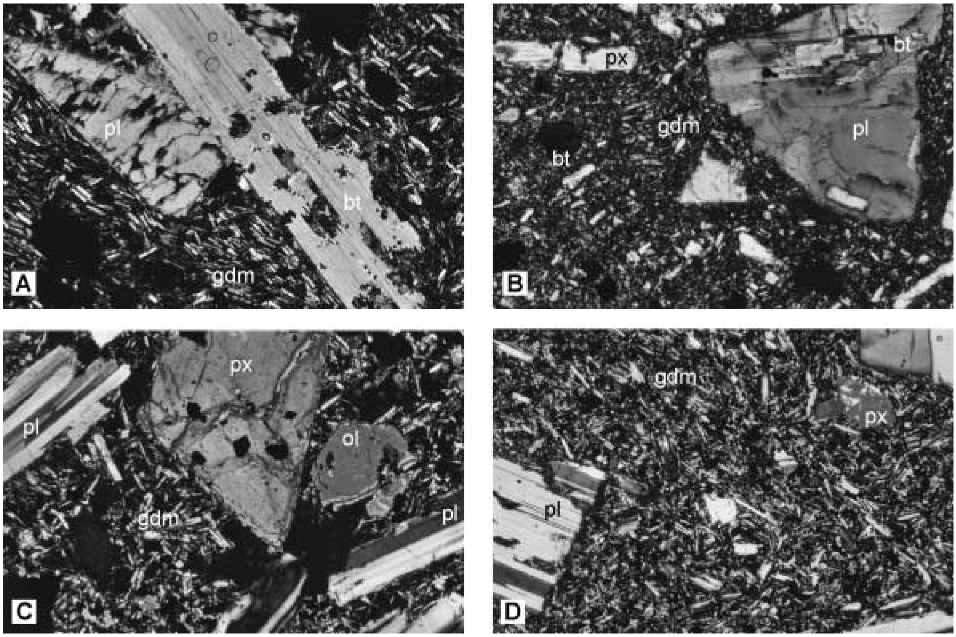

Figure 4 *Thin-section photomicrographs (crossed nicols; long side length 2.4 mm). (A) An aspect of a trachytic saddle-quern (sample CPO1): plagioclase (pl) and biotite (bt) phenocrysts are set in a microcrystalline-pilotaxitic groundmass (gdm). (B) An aspect of a trachytic rotary millstone of Roman age (sample CP5): plagioclase, biotite and pyroxene (px) phenocrysts are set in a microcrystalline groundmass. (C) An aspect of hawaiite (sample CSL6): pyroxene, olivine (ol) and plagioclase phenocrysts are set in a microcrystalline-intergranular groundmass. (D) An aspect of mugearite (sample CSD1): plagioclase and pyroxene phenocrysts are set in a microcrystalline-intergranular groundmass.*

As far as the archaeological pieces made of basic lavas are concerned, an extensional within-plate regime for the generation of the related magmas is constrained by the determined Th/Nb ratios (see, e.g., Fig. 8 of Beccaluva *et al.* 1991). Among some important within-plate basic volcanites of the Mediterranean, the basalts of Monte Etna, in Sicily (Cristofolini and Romano 1982; Cristofolini *et al.* 1991; Corsaro and Cristofolini 1996) are those that best fit the petrographic (Table 2) and geochemical (Table 3 and Fig. 7) characteristics of the studied grinding tools. On the contrary, the alkali basalts of possible alternative sources, such as the Venetian Magmatic Province (De Vecchi *et al.* 1976; Milani *et al.* 1999), the Carpathians and the Pannonian Basin (Embey-Isztin *et al.* 1993; Ivan and Hovorka 1993; Dobosi *et al.* 1995; Harangi *et al.* 1995) are quite different in terms of petrographic and chemical compositions (Figs 7 (b) and 8). Therefore, we suggest Mount Etna as the most probable source exploited for our materials.

CONCLUSIONS

The results of the petrographic and geochemical analyses are important for the archaeological interpretation of the artefacts and, more extensively, of the sites of discovery.

The fact that 26 out of the 30 grinding tools are certainly made of trachytes from the Euganean Hills would indicate a preferential source of procurement of the raw materials used to

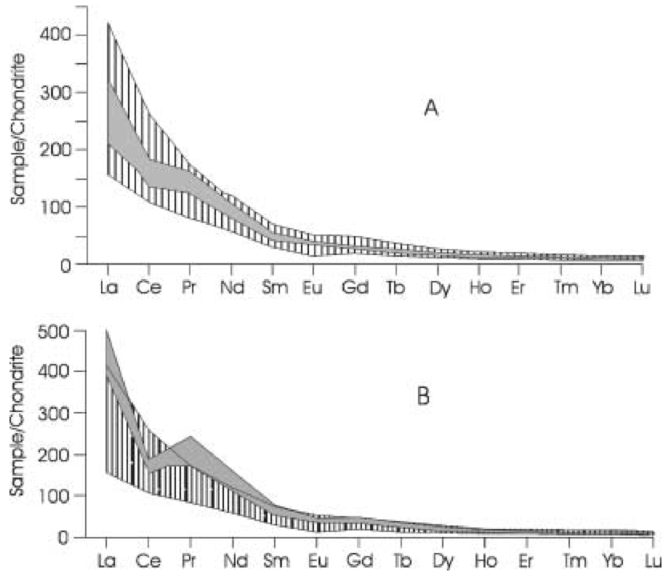

Figure 5 *The REE distribution of millstones (grey) and of Euganean trachytes (stippled): (A) protohistoric and Roman grinding tools; (B) grinding tools CSL1, CSL3, CS1 and CS7, showing Ce anomalies (grey field). The REE data of Euganean rocks are unpublished data (Capedri). Normalizing values from Anders and Grevesse (1989) multiplied by a factor of 1.36 as proposed by Korotev (2000).*

produce them, although not the exclusive one: volcanic rocks of different origins and sedimentary rocks (unpublished data) are in fact also documented.

We cannot say whether or not these different raw materials were used contemporaneously, because all of the pieces have been found out of stratigraphic context, and their typological characteristics are not sufficiently clear to be discriminative in terms of chronology (apart from the rotary querns of Roman age).

Nevertheless, if we focus not on the single pieces and their possible associations, but on the groups of artefacts (or fragments of rocks) with the same petrographic nature, we can try to restrict the period of their introduction into the local contexts, and of their probable use, by turning to indirect evidence. In the case of the saddle-querns (or fragments attributed to saddle-querns), whose likely origin is in the Monte Altore and Rocca Pendice areas of the Euganean Hills, we know that similar artefacts have been found at various sites in northern Italy dated from the seventh to the fifth century BC (Cattani *et al.* 1997); the time-span is even shorter—from the sixth to the fifth century BC, when one specific type is considered (type A of the typology of Cattani *et al.* 1997, CSL2 in the samples under examination). We also know that the exploitation and trade of trachytes from the Euganean Hills were controlled by the Veneti, a very important population group who were very influential in the northern Italian regions and beyond.

The presence in the Karst and in Istria of other exchanged or traded objects produced within the same Venetic area could further support the cultural and chronological connections suggested by the grinding tools. For instance, fragments of *situlae* have been found in the *castelliere* of Monrupino (Lonza 1972; Maselli Scotti 1983)—where a saddle-quern is also documented—as well as in other four *castellieri* of the Karst: Rupinpiccolo (Maselli Scotti 1983), Sales (Cannarella 1981), Cattinara (unpublished data) and S. Canziano (Turk pers.

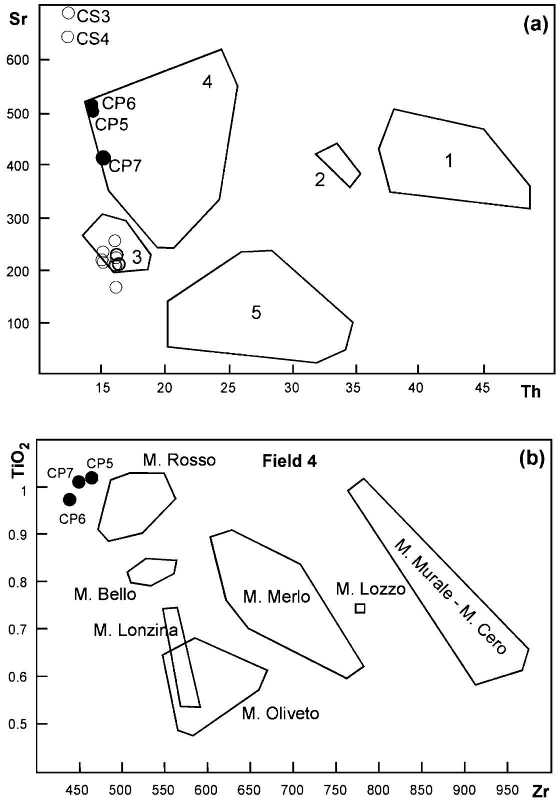

Figure 6 (a) The Sr versus Th diagram used for the discrimination of the trachytes of the Euganean Hills (from Capedri et al. *2000). Field 1, Monselice; field 2, Mt Trevisan; field 3, Mt Altore and Mt Pendice; field 4, Mt Oliveto, Mt Bello, Mt Cero, Mt Lonzina, Mt Lozzo, Mt Merlo, Mt Murale and Mt Rosso; field 5, Mt Alto, Mt Grande, Mt Lispida, Mt Oliveto 2, Mt Rusta and Mt San Daniele. (b) The TiO_2 versus Zr diagram for the discrimination of the Euganean trachytes plotting in field 4 of Figure 6 (a) (from Capedri* et al. *2000).*

comm.). *Situlae*—that is, fine red-and-black-striped vessels—are a typical pottery product of the Venetic area from the end of the seventh to the fifth century BC (Este III B2 – Este III C) (Fogolari and Prosdocimi 1987; Capuis 1993; Peroni 1996). These data would indicate that this part of *Caput Adriae* (i.e., the regions bordering the northeastern Adriatic Sea) already had direct or mediated contacts with the Veneti towards the end of the seventh century BC.

Saddle-querns, in the form of either finished tools or raw materials for local manufacture, might have been part of the same mechanisms of contact, moving along the same routes to the Karst and possibly beyond. The intensity of these contacts might have decreased with increasing of distance from the source, as the present data seem to suggest: 19 out of the 20 grinding tools of volcanic rocks found in the Trieste Karst would seem to come from the Monte Altore and Rocca Pendice areas of the Euganean Hills (19 out of the total 24 samples of this lithology), while this type of rock represents slightly more than 50% of the exotic materials at two Slovenian and Croatian sites (the *castellieri* of Povir and Pizzughi II) and is totally absent in the remaining two (the *castellieri* of S. Dionisio and S. Martino). However, more evidence is needed to check this last hypothesis.

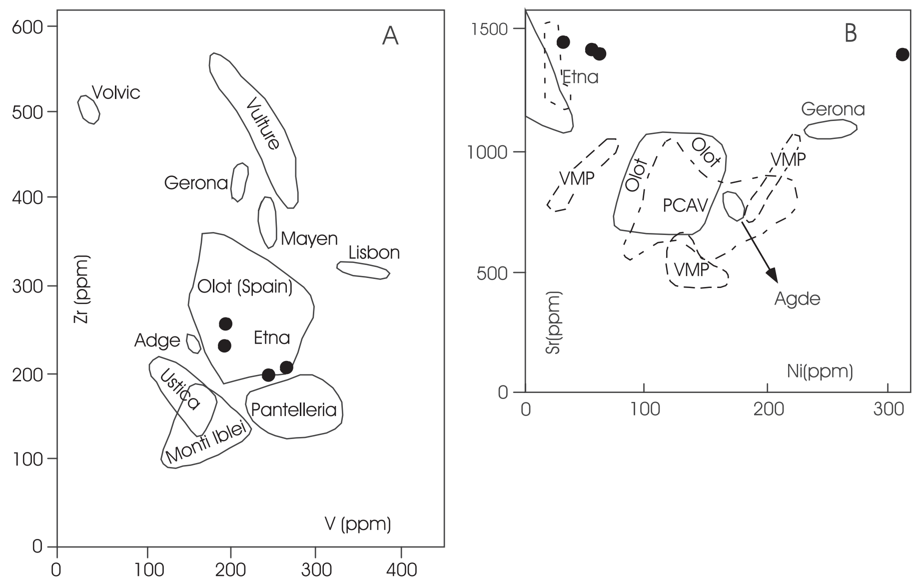

Figure 7 *The distribution of Zr and V (A) and of Ni and Sr (B) of some important Mediterranean within-plate volcanites (from Thorpe-Williams and Thorpe 1990; B modified). Solid circle, analysed millstones; short broken line, hawaiites and mugearites from 'Mongibello Recente', Etna (data from Cristofolini* et al. *1991); VMP (long broken line, Venetian Magmatic Province (data from Milani* et al. *1999); PCAV (short and long broken line), alkaline basalts from the Pannonian Basin and Carpathian Arc (data from Embey-Isztin* et al. *1993; Ivan and Hovorka 1993; Dobosi* et al. *1995; Harangi* et al. *1995).*

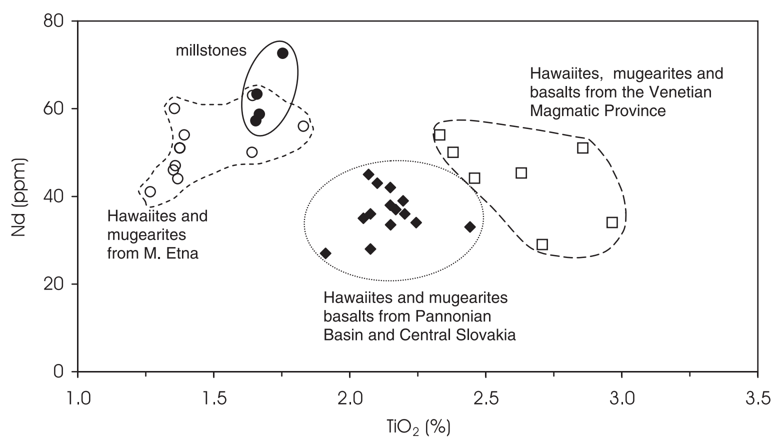

Figure 8 *TiO_2/Nd ratios of Etnean, Venetian and Pannonian-Carpathian alkaline basalts. Solid circles, analysed millstones; open circles, hawaiites and mugearites from 'Mongibello Recente', Etna (data from Cristofolini* et al. *1991); squares, hawaiites, mugearites and basalts from the Venetian Magmatic Province (data from Milani* et al. *1999); diamonds, hawaiites, mugearites and basalts from the Pannonian Basin and Carpathian Arc (data from Embey-Isztin* et al. *1993; Ivan and Hovorka 1993; Dobosi* et al. *1995; Harangi* et al. *1995).*

The present lack of materials coming from the other Euganean area of Monte Rosso in the Karst—the only three pieces attributed to this source have been found in the *castelliere* of Pizzughi II—does not exclude the possibility that this area acted as an intermediary (but certainly makes it weaker). Moreover, the likely attribution of the three fragments of rotary querns to the Roman age would indicate that the connections between Veneto and the regions to the east operated over a long period, from the late protohistoric into historical times, although presumably with some form of continuity.

As far as the two hawaiite and the two mugearite fragments are concerned, we can tentatively assume that they reached *Caput Adriae* through maritime routes no earlier than the sixth century BC. In fact, recent studies by Lorenzoni *et al*. (2000a,b) indicate that hawaiites and mugearites from Mount Etna reached Puglia and the neighbouring areas from the sixth century BC onwards: this phenomenon would correspond to an increase and a diversification in the exploitation of volcanic sources, as well as to an extension of the trading connections, particularly those by sea. These data, together with the fact that the relations between southern Italy and the northeastern Adriatic coast are also demonstrated by other materials (see, e.g., Mihovilić 2001), could support our hypothesis that the fragments interpreted as parts of saddle-querns reached the area under investigation at some time in the late protohistoric.[1]

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[1] When this study was almost at its end, we learnt about four new grinding tools: two fragments of saddle-querns from the *castelliere* of Cattinara—one from the old investigations of Marchesetti and one found in the excavations carried out in 2003 by the local Soprintendenza—a similar artefact from Villanova in Istria and one piece of rotary quern from Povir. In a preliminary, quick petrographic analysis, the rock used to manufacture the latter could come from Monte Rosso, while a more generic provenance from the Euganean Hills can be postulated for the former. If confirmed, these new data will strengthen the interpretations presented in this study.

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