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Review

Mediterranean trade of the most widespread Roman volcanic millstones from Italy and petrochemical markers of their raw materials

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ABSTRACT

The petrochemical study of millstones can contribute to improve the archaeological research into reconstruction of ancient communication routes and trade networks. Volcanic rocks are geographically restricted and rather rare in the Mediterranean regions, and during the Roman period Italian volcanoes were important sources of raw materials for millstones, so the task of determining their geological origin is relatively straightforward. The Italian vesicular volcanics most frequently employed for this purpose were: trachytes from Euganean Hills (Veneto), leucite-bearing lavas from the *Vulsini Volcanic District* (Latium), basic-intermediate leucite-bearing lavas from Somma-Vesuvius (Campania), silica undersaturated lavas from Monte Vulture Volcano (Basilicata), a rhyolitic ignimbrite from Sardinia and basic products from Mount Etna and the island of Pantelleria (Sicily). This paper contains a general outline of the trade network for each volcanic typology used for millstones during the Roman period – updated with data concerning the leucite-bearing lavic items discovered in the archaeological sites of the ancient *Cuicul* (now Djemila, Algeria) – together with a summary of their petrographic and geochemical features.

1. Introduction

It is generally acknowledged that archaeometric research on mills and millstones found in the Mediterranean area is an important means for the identification of the production sites of these artefacts and for the rediscovery of important trade networks of protohistory and history. During the Roman age, hourglass-shaped or flat, cylindrical rotary millstones were exported to and imported from many provinces of the Empire, including Germany, France, Italy, Spain, Portugal, Morocco, Tunisia, Libya, Algeria, Cyprus and Turkey (cf. Williams-Thorpe, 1988; Antonelli et al., 2001, 2005 and bibliography therein). Most of these Roman millstones discovered in archaeological sites throughout the Mediterranean are made of volcanic rock. In fact, lavas are generally wear-resistant and they are particularly suitable for milling because of their abrasive property (hard enough not to contaminate the flour unduly) and rough vesicular surface that provides a good grinding capacity. The mills most commonly used by the Romans were up to 1.5 metres high (Fig. 1) and typically consisted of an hourglass-shaped (double-cone) upper stone (*catillus*) resting on the conical lower stone (*meta*) (Moriz, 1958). The *catillus* was turned on the *meta* by means of a bar pushed by slaves or a donkey (*mola asinaria* or *iumentaria;* donkeymills). As proposed by Antonelli et al., 2001, re-interpreting Varro (the Latin scholar of the first century BC) rotary millstones (*molae versatiles*) were most probably invented (no later than the fourth century BC) in *Volsinii veteres* (present-day Orvieto), the famous Etruscan village, and not simply in *Volsinii* (or *Volsinii novi*, now Bolsena), the Roman city built in the first half of the third century BC close to Bolsena Lake, ca 8 km NE of Orvieto. Rotary millstones hourglass-shaped are also known as Pompeian-style millstones after the site where they occur so frequently and were first discovered (i.e. Pompeii-Naples; Peacock, 1989; Buffone et al., 2003). Other famous Italian archaeological sites where well-preserved examples have been discovered include Ostia Antica (Rome) and Aquileia (Udine). They were a very popular item, highly prized in Roman bakeries and military settlements of the Imperial provinces. Shipwrecked cargoes of millstones such as that of Sec (Mallorca, Spain; Williams-Thorpe and Thorpe, 1990), testify both to their importance in the Roman period and to the fact that they were traded throughout the eastern and western Mediterranean. Fortunately, seeing that volcanic complexes occur in few regions of the Mediterranean basin, volcanic rocks exploited for millstones may be very important markers for reconstruction of ancient commercial and communication routes. Old and recent works (Peacock, 1980, 1986, 1989; Ferla et al., 1984; Williams-Thorpe, 1988; Williams-Thorpe and Thorpe, 1989, 1990, 1991, 1993; Lorenzoni et al., 1996, 2000a,b; Oliva et al., 1999; Antonelli

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Fig. 1. Classical Pompeiian-style millstones. (a) *Pistrinum* of Pompeii; (b) Aquileia, Archaeological Museum; (c) *Pistrinum* of Ostia Antica.

Table 1
Whole rock major oxides (wt%) and trace elements (ppm) analyzed for Roman lavic millstone D, D3, D4 discovered in the archaeological site of the ancient *Cuicul* (Djemila, Algeria). An average (OR-AV) of 11 analyses (of leucite phonolite lavas from the Orvieto quarries (after Antonelli et al., 2001) is reported for the purposes of comparison. Standard-deviation (σ) of the average values OR-AV with respect to the quarry samples of Antonelli et al. (2001) are also reported. Analyses were performed at the ALS Chemex Laboratory Group (Vancouver, Canada) by ICP-OES-MS methods. Errors were ≤1% for major oxides and ≤5% for trace elements.

Sample	D	D3	D4	OR-AV	σ
wt%					
SiO_2	55.20	54.60	54.00	56.35	0.36
Al_2O_3	20.00	18.60	19.85	21.42	0.13
Fe_2O_3	4.37	3.77	3.41	4.37	0.15
MnO	0.16	0.14	0.13	0.13	0.01
MgO	0.83	0.71	0.79	0.81	0.03
CaO	3.84	4.86	4.91	3.57	0.09
Na_2O	2.98	3.27	2.63	2.79	0.42
K_2O	8.48	8.25	10.55	9.95	0.30
TiO_2	0.53	0.47	0.41	0.50	0.02
P_2O_5	0.13	0.16	0.25	0.10	0.01
LOI	2.86	2.85	2.78	–	–
Total	99.38	97.68	99.71	99.99	–
K_2O/Na_2O	2.85	2.52	4.01	3.57	–
ppm					
V	143	120	114	125	19.45
Cr	<10	<10	<10	2.67	1.0
Co	6.50	5.70	5.80	5.56	0.3
Ni	<5	<5	<5	4.00	0.9
Rb	278	282	396	352	40.0
Sr	2100	2170	1865	1947	61.0
Y	39	35	30	39	1.6
Zr	811	649	558	730	69.0
Nb	54.1	48.0	36.6	45.0	1.9
Ba	2300	2430	2120	2232	44.0
La	204	183	144	183	7.0
Ce	394	316	255	325	12.0
Nd	121	108	87	107	4.0
Sm	18.05	16.05	13.10	16.10	0.50
Gd	17.00	15.00	12.15	11.30	0.60
Dy	8.17	7.20	6.04	7.18	0.32
Er	4.61	4.22	3.38	3.42	0.13
Yb	4.05	3.64	2.96	3.35	0.12
Lu	0.57	0.52	0.42	0.51	0.02
Hf	13.10	11.60	9.50	10.80	0.40
Th	144	126.5	95.6	160	9

et al., 2000, 2001, 2004, 2005; Renzulli et al., 2002a; Santi et al., 2004; Buffone et al., 2003) have combined to establish a useful petrographic, geochemical and historical database on the source areas for the grinding tools used in Mediterranean countries from the Neolithic to the Roman periods.

The purpose of this paper is to give a concise overview of the main Italian volcanic rocks exploited by the Romans in the manufacture of exported millstones as well as of their trade network. The general outline is updated with new data referring to leucite phonolite mills discovered at the archaeological site of ancient *Cuicul* (now Djemila, Algeria) (cf. Figs. 4–6 and Table 1).

2. Quarrying areas and circulation of the artifacts

The Romans exploited several Italian lava sources (Fig. 2), generally vesicular and so relatively easy to work, to produce millstones and rotary querns; judging by the archaeological finds the most widespread were (from northern to southern Italy): (i) Na-trachytes from the Euganean Hills (Padua – Veneto); (ii) leucite phonolites from quarries in the *Vulsini Volcanic District* (near Orvieto – Latium); (iii) leucite basaltic trachyandesites of Somma-Vesuvius (Naples – Campania) and (iv) tephrites-foidites from Vulture (Potenza – Basilicata); (v) volcanic rocks from Sardinia, chiefly rhyolitic ignimbrite from Mulargia and, to a very minor extent, the grey vesicular subalkaline basalts from different parts of the island (not considered here); (vi) hawaiites, mugearites and basalts from Etna (Catania – Sicily) as well as, to a minor extent, some other Sicilian basic lavas from Hyblean Plateau and the islands of Pantelleria, Ustica and Lipari. However, according to the archaeological and archaeometric evidence, volcanics (iii), (v) and (vi) were generally preferred by Romans for export on a medium-large scale, (i)–(ii) were exported on a medium-to-small scale, whereas the lavas from Vulture (iv) were seldom transported far from the production centres and basically employed locally and on a small scale.

2.1. Trachytic rocks from the Euganean Hills – Venetian Volcanic Province

The Euganean Hills, located in North-Eastern Italy (province of Padua) within the Venetian Tertiary Volcanic Province, comprise 81 domes whose origin is related to the extensional tectonic regime of the South-Alpine foreland (De Pieri et al., 1983) and the extensive eruptive activity that took place from the late Paleocene to the late