

PROVENANCE STUDY OF A BASALTIC MILLSTONE FROM THE BYZANTINE MONASTERY IN NAḤAL QIDRON, JERUSALEM

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During excavations of a monastery near Jerusalem, a basaltic millstone of an unusual type was discovered; it was dated by the excavators to the Byzantine period (see Zelinger and Barbé, this volume: Figs. 29, 30). The aim of this study is to define the chemical composition of the millstone and to attempt to provenance it.

Among the few publications of provenance studies of basalts, two by Williams-Thorpe et al. (1991) and Williams-Thorpe and Thorpe (1993) present databases for chemical analyses of basaltic millstones from the eastern Mediterranean, ranging in date from the Neolithic to Roman periods. The present author has studied basaltic millstones from a number of sites in Israel: Naḥal Tut and 'En Ḥofez, dated to the second half of the fourth century BCE (Segal 2006); Ramat Ha-Nadiv, dated to the Hellenistic–Roman periods (Segal, forthcoming [a]); the Burnt House in Jerusalem, from the Roman period (Segal 2010), and Naḥal Tanninim, from the Byzantine period (Segal, forthcoming [b]). Comparison of the chemical composition of the basalts from these sites with the databases published by Williams-Thorpe and Thorpe

(1993) revealed that all the millstones from Naḥal Tanninim (n = 6) and Ramat Ha-Nadiv (n = 4), one from 'En Ḥofez and six from the Burnt House can be sourced to the area of Tiberias in Israel. Two millstones from Naḥal Tut, one from 'En Ḥofez, and a basalt vase from the Burnt House originated in Nisyros Island in the Aegean Sea.

Sampling and Analytical Procedure

A powder sample was achieved by drilling with a stainless-steel drill, a sampling method that has been shown to produce no contaminations (Segal 2010). Chemical analyses of major elements and Zr were performed using fusion with lithium metaborate, followed by measuring concentration with an inductively coupled plasma atomic emission spectrometer (ICP-AES, Optima 3300, Perkin Elmer). For minor and trace-element determination, samples were dissolved using sintering with sodium peroxide. After dissolution, elements Cr, Cu, Zn, Ba and Sr were determined using the ICP-AES spectrometer, and elements V, Co, Ni, Mo, Rb, Nb, Pb, Th and U, by the ICP mass spectrometer (ICP-MS, Elan DRC II, Perkin Elmer Sciex).

Table 1. Chemical Composition of the Basaltic Millstones

Elements Measured in Wt. %															
SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	CaO	MgO	MnO	Na ₂ O	K ₂ O	P ₂ O ₅	SO ₃					
50.0	15.1	12.0	2.0	9.5	7.5	0.17	3.0	0.56	<0.2	<0.2					
Elements Measured in ppm															
V	Cr	Co	Ni	Cu	Zn	Rb	Nb	Mo	Pb	Th	U	Ba	Sr	Zr	
289	443	68	197	102	109	11	18	1.18	375	1.4	0.42	180	340	130	

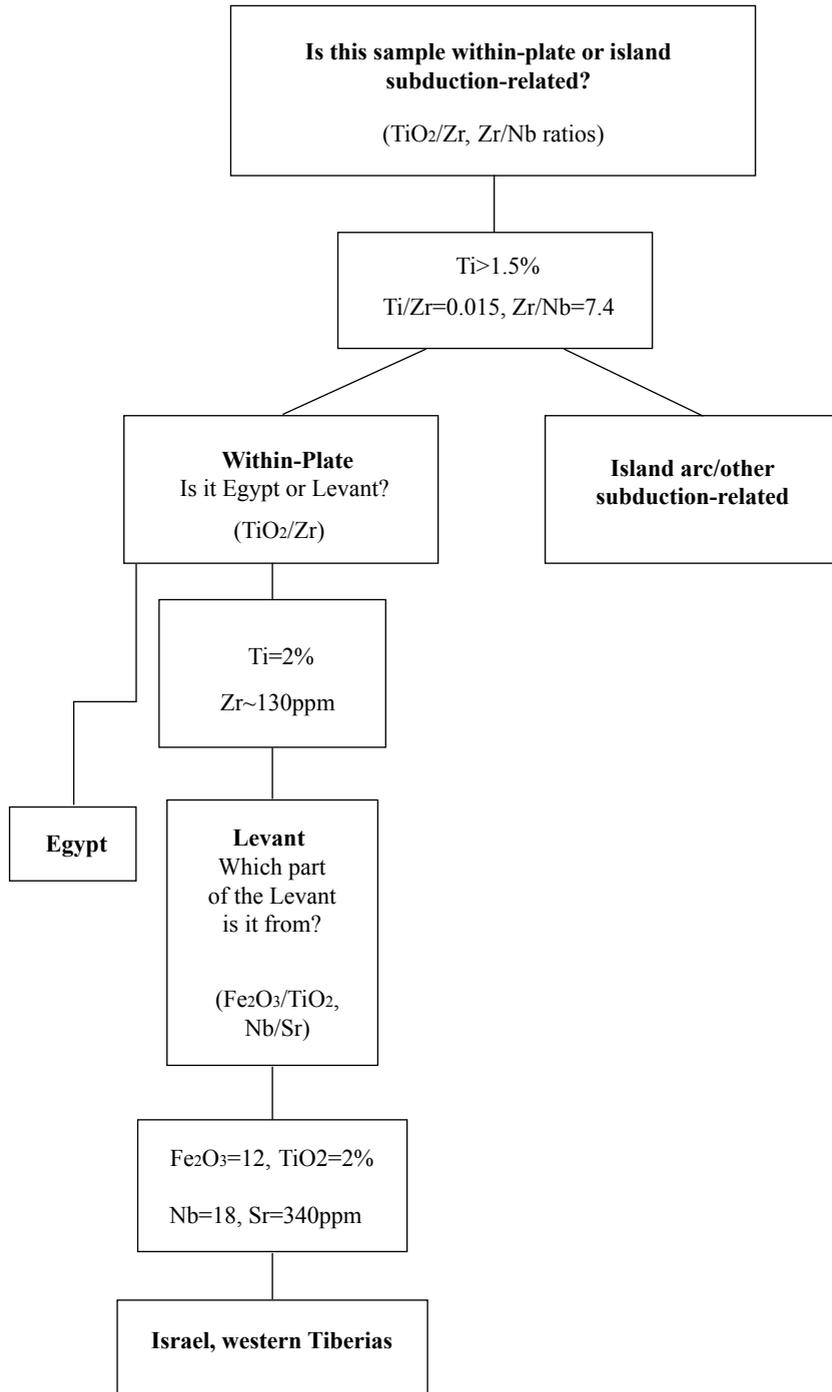


Fig. 1. Flow diagram demonstrating the procedure for provenancing basalt (after Williams-Thorpe and Thorpe 1993).

Results and Discussion

The results of the chemical analysis are presented in Table 1. The provenance study was conducted following the guidelines set out by Williams-Thorpe (1988), Williams-Thorpe et al. (1991) and Williams-Thorpe and Thorpe (1993). For the Mediterranean region, the source assignment is represented by the flow diagram (Fig. 1), where diagnostic elements for each stage are shown. The results were first plotted on a graph of TiO_2 vs Zr (Williams-Thorpe and Thorpe 1993: Fig. 9). This allows a first assignment to its tectonic setting. In the present sample, the TiO_2 content is relatively high (2%) and Zr content is 130 ppm; thus, the sample originates within plate rock (continental) and not a volcanic-island arc. In addition, the Zr:Nb ratio of 7.4 also points to a within-plate origin, as island-arc basalts have higher ratios, typically between 12 and 25.

Sources of within-plate basaltic rocks in the eastern Mediterranean are Egypt, and Levant volcanics in Israel, Jordan and Syria. Rocks from these two regions may be distinguished using the TiO_2/Zr ratio (Williams-Thorpe and Thorpe 1993: Fig. 15). In the present sample, the TiO_2 and Zr contents (2% and 130 ppm respectively) place the sample in the Levantine field, as Egyptian basalts have a higher TiO_2 content

(>2.5%). Williams-Thorpe and Thorpe (1993: Fig. 16) demonstrated that the rotary millstones have Nb and Ni concentrations in ranges of 14–19 and 140–200 ppm respectively, and as the studied sample has Nb and Ni concentrations of 18 and 197 ppm, it corresponds to this type.

To define more precisely the basaltic source within the Levant, we must compare the Fe, Ti, Nb and Sr concentrations to those published by Williams-Thorpe and Thorpe (1993). While the Fe_2O_3 and TiO_2 contents (12 and 2% respectively) locate the sample exactly on the border of the Tiberias basaltic field, the Nb and Sr contents (18 and 340 ppm) place the sample in the western part of the Tiberias field. Therefore, the millstone from the Byzantine monastery was made of basaltic rock procured from the area west of Tiberias.

Conclusions

The chemical composition of the studied basaltic millstone from the Byzantine monastery in Naḥal Qidron demonstrates that, based on its Nb and Ni contents, it corresponds to Williams-Thorpe and Thorpe's rotary-quern type. The provenance study reveals that its source is in the western Tiberias basaltic field. These results indicate the dominance of basalt sources in Israel, rather than the Aegean, in basaltic-tool production.

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