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The use of SEM-EDS, PIXE and EDXRF for obsidian provenance studies in the Near East: a case study from Neolithic Çatalhöyük (central Anatolia)☆

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ABSTRACT

In this paper we evaluate the relative analytical capabilities of SEM-EDS, PIXE and EDXRF for characterizing archaeologically significant Anatolian obsidians on the basis of their elemental compositions. The study involves 54 geological samples from various sources, together with an archaeological case study involving 100 artifacts from Neolithic Çatalhöyük (central Anatolia). With each technique the artifacts formed two compositional groups that correlated with the East Göllü Dağ and Nenezi Dağ sources. The non-destructive capabilities of these methods are emphasized (albeit with certain analytical limitations in the case of SEM-EDS), suggesting important new techniques for Near Eastern obsidian provenance studies.

1. Introduction

Obsidian was the primary raw material used by the inhabitants of Çatalhöyük (Konya Plain, central Anatolia) for the manufacture of their chipped stone tools throughout its Aceramic Neolithic – Early Chalcolithic occupation (c.7400–5500 cal BC, Cessford et al., 2005), despite the fact that the nearest sources are located ≥190 km to the northeast in the volcanic region of Cappadocia (Fig. 1). In 1999, as part of the renewed work at the site, a major program of obsidian characterization was initiated to investigate the long-term use of obsidian at Çatalhöyük. From the outset this work involved more than one laboratory and employed a range of analytical techniques (Table 1), i.e. our project is interested not only in the archaeological ramifications of our analyses, but also the collaborative development of innovative archaeometric approaches.

☆ This article is dedicated to the late Joseph Salomon, a former leading member of the AGLAE research group of the Centre de Recherche et de Restauration des Musées de France (Paris), with whom some of us initiated this obsidian provenance program fifteen years ago, Joseph, who passed away a few months ago, was a close collaborator and friend of several of the authors, and we feel both scientifically and humanly indebted to him.

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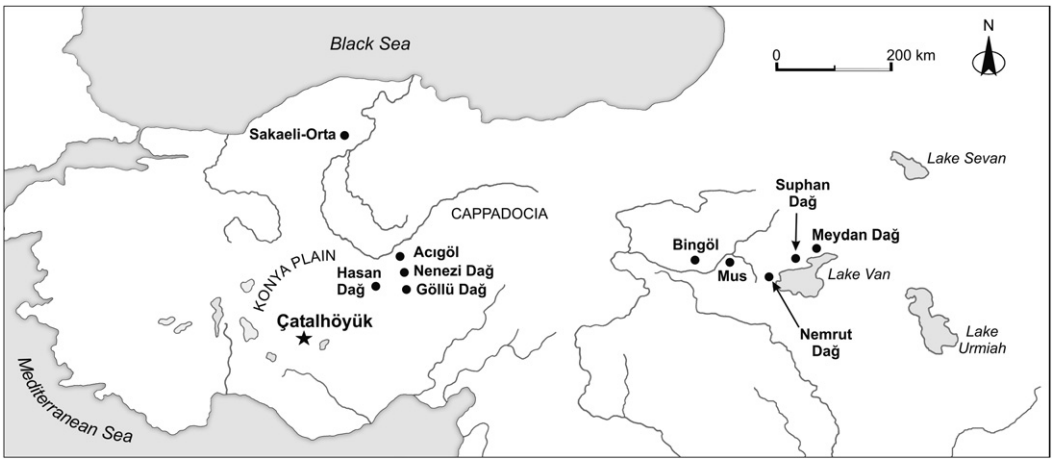

Fig. 1. Map of Anatolia showing the location of Çatalhöyük and the obsidian sources cited in the text.

Recent work at CRP2A (Bordeaux) has involved the investigation of two non-destructive analytical techniques that have received little, or no previous application in Near Eastern obsidian sourcing studies, namely scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) (Keller and Seifried, 1990; Delerue, 2007; Delerue and Poupeau, 2007) and particle induced x-ray emission (PIXE) (Abbès et al., 2003; Le Bourdonnec et al., 2005; Delerue, 2007; Carter et al., 2008). This paper focuses initially on the ability of these two methods to chemically discriminate some of the major Anatolian obsidian sources and to report new sourcing data using these approaches on 100 obsidian artifacts from Aceramic – Early Pottery Neolithic Çatalhöyük. Issues raised with some of the SEM-EDS data further led us to employ EDXRF, both as a means of analytical 'check and balance' and to integrate further another of the labs involved in our long-term international multi-technique/-researcher approach. The focus of this paper is therefore largely methodological, whereby the integrated *chaîne opératoire* analytical framework advocated by our team (Carter et al., 2006, 893–895), is detailed fully in a companion paper.

2. Provenance studies at Çatalhöyük

Çatalhöyük has long enjoyed a relationship with characterization studies, with four blades from the site included in the very first analysis of Near Eastern obsidians using OES in the 1960s (Renfrew et al., 1966), followed by the analysis of a further 11 artifacts over the next 35 years by OES, XRF and strontium isotope analyses (Gale, 1981; Keller and Seifried, 1990; Wright, 1969). Our new program of analyses has since characterized a further 527 samples, 100 of which form the archaeological basis of this paper (Table 1). While allowing for certain changes in source nomenclature over the past 40 years (Chataigner, 1998; Poidevin, 1998), the following general statements can be made concerning the history of obsidian use at Çatalhöyük (see Table 1 for all references): (1) throughout its history the two main sources exploited were East Göllü Dağ and Nenezi Dağ in southern Cappadocia (Fig. 1); (2) these obsidians were often consumed differently with regard to how they were worked and what was made from them, distinctions that cannot be explained through reference to mechanical properties alone; (3) the relative importance of these raw materials changed through time in terms of their proportion of the total obsidian assemblage; (4) during the later Early Pottery Neolithic (East Mound, Levels VI and upward) and Early Chalcolithic (West Mound) tiny quantities of obsidian were also procured from northern Cappadocian sources such as West Acıgöl and East Acıgöl ante caldera; (5) later Early Pottery Neolithic and Early Chalcolithic contexts have produced a handful of ready-made pressure-flaked blades made from eastern Anatolian obsidians, mainly the distinctive green peralkaline raw materials associated with the mountains of Bingöl and/or Nemrut Dağ, plus one made of a calc-alkaline product of Bingöl, sources located some 650–825 km distant, extending the western distribution of these obsidians by 300 km.

Table 1
Total number of Çatalhöyük obsidian artifacts sourced by our group and techniques used.

Laboratory	Artifacts[a]	Techniques	Publication
Grenoble (LGCA-CNRS)	100 (101)	ICP-AES; ICP-MS	Carter et al. (2005a, 2006)
Aberystwyth	35	LA-ICP-MS	Carter et al. (2005a, 2006)
Berkeley (2003)	42	EDXRF	Carter and Shackley (2007)
Bordeaux (CENBG-CNRS)	62 (62)	PIXE	This paper
Paris (C2RMF-CNRS) (2005)	10 (10)	PIXE	This paper
Bordeaux (IRAMAT-CNRS)	51	SEM-EDS	This paper
Berkeley (2008a)	34[b]	EDXRF	This paper
Berkeley (2007)	48 (53)	EDXRF	*in prep.*
Berkeley (2008b)	100	EDXRF	*in prep.*
Paris (C2RMF-CNRS) (2007a)	42 (46)	PIXE	Carter et al. (2008); *in prep.*
Paris (C2RMF-CNRS) (2007b)	15	PIXE	*in prep.*
Stanford	45	ICP-AES	*in prep.*
Total artifacts analyzed	557 (584)		

[a] The number in parentheses refer to the total number of analyses. Some artifacts have been measured more than once (by different labs).
[b] These artifacts and 17 others traited by PIXE were initially analyzed by SEM-EDS at IRAMAT-CNRS, they are not counted as new artifacts.