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SOURCING OBSIDIAN FROM NEOLITHIC ÇATALHÖYÜK (TURKEY) USING ENERGY DISPERSIVE X-RAY FLUORESCENCE*

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This paper details the chemical sourcing of 42 obsidian artefacts from a single Neolithic structure at Çatalhöyük (central Anatolia), using Energy Dispersive X-Ray Fluorescence (EDXRF). The chemical signatures of the samples match those of two geological sources in southern Cappadocia: East Göllü Dağ and Nenezi Dağ. The data provide a counterpoint for previous analyses at the site, and suggest possible intra-community distinctions with regard to shifts in raw material procurement and technical change.

KEYWORDS: OBSIDIAN SOURCING, ÇATALHÖYÜK, NEOLITHIC, EDXRF, EAST GÖLLÜ DAĞ, NENEZI DAĞ

INTRODUCTION

Located in central Anatolia's Konya Plain (Fig. 1), the site of Çatalhöyük comprises two artificial mounds that rise above a flat, seasonally flooded plain (Fig. 2). The earlier and more famous East Mound is primarily of Neolithic date (settled in the Aceramic Neolithic), its excavation in the 1960s revealing a remarkable settlement of 32 acres, *the world's first city* (Mellaart 1967), with 15 building levels superimposed upon one another and a population that at its peak was anywhere between 3500 and 8000 people (Cessford 2005). Radiometric dating provides us with a chronological range of *c*. 7400–5600 cal BC for the mound's occupation, from its basal strata (Level Pre-XII.D) up to Level II (Cessford *et al.* 2005). While Çatalhöyük was a remarkable settlement for its time, its location was an extremely poor one in terms of everyday resources. Aside from a never-ending supply of mud (the main building material), virtually everything the community required to roof their houses, make their tools and—to an extent—feed themselves, had to come from afar (Mellaart 1967, 212; Fairburn *et al.* 2002, 49–53). This is particularly true of obsidian, the main raw material for their flaked implements (usually > 95% of any assemblage), the closest sources of which lay some 190 km distant to the north-east, in the volcanic region of Cappadocia (Fig. 1).

The sheer quantity of obsidian at the site led the first excavator to argue that the resource was of major economic significance to the community, their primary exchange commodity, with Çatalhöyük controlling the Cappadocian sources and monopolizing the material's trade throughout Anatolia, Cyprus and the Near East (Mellaart 1967, 177). A wall-painting from

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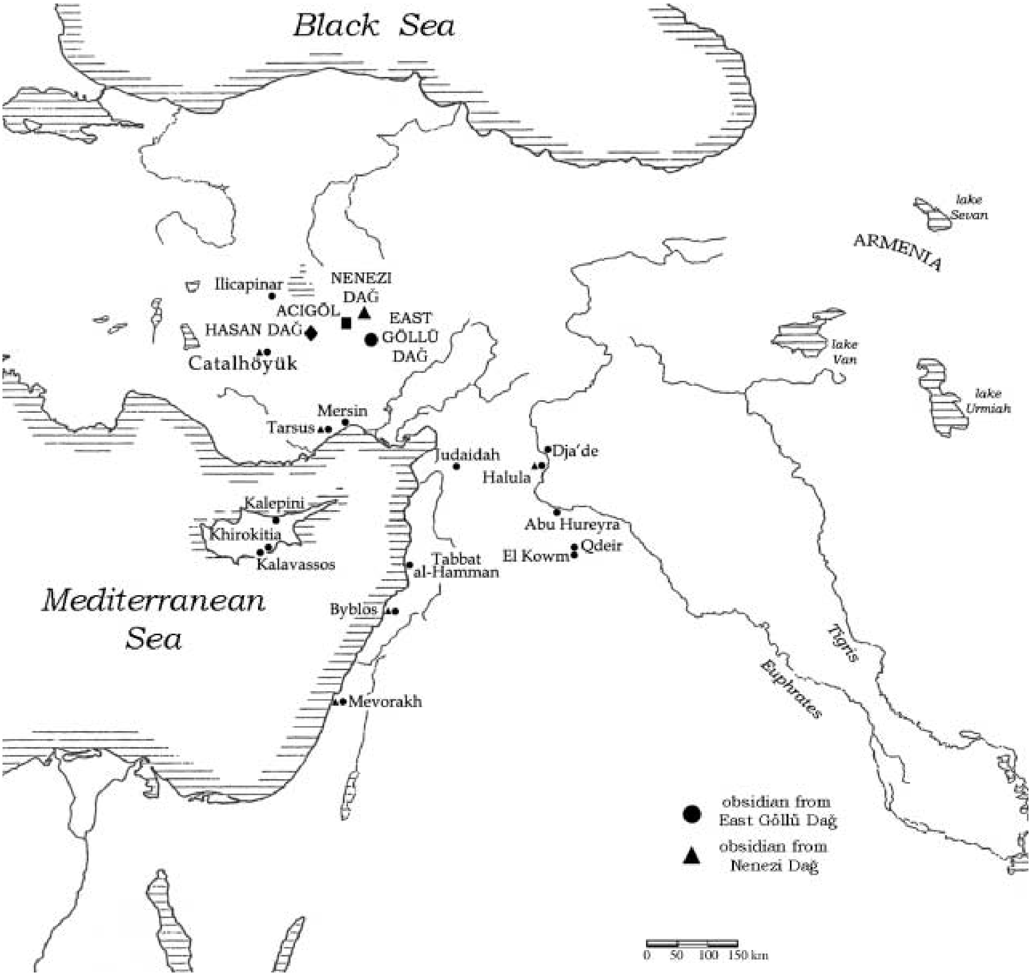

Figure 1 *A map showing the obsidian sources and sites mentioned in the text (M. Milić).*

one of the site's 'shrines' was claimed to show Hasan Dağ (with Çatalhöyük shown in the foreground), the closest of Cappadocia's obsidian-bearing mountains. This distinctive double-peaked volcano is occasionally visible from the site, its depiction allegedly symbolizing the importance of the raw material *from which the site probably derived much of its wealth* (Mellaart 1967, 177, pls. 59–60).

Some 40 years later, we now know that the widespread dissemination of Cappadocian obsidians predates the establishment of Çatalhöyük by millennia, with East Göllü Dağ obsidian recovered from Epi-Palaeolithic sites (12 000–10 000 BC) in the Middle Euphrates and southern Levant (Cauvin and Chataigner 1998, 330–1). Moreover, most of the Cappadocian obsidian put into circulation during the Neolithic—including the period of Çatalhöyük's occupation—was consumed by communities to the east and south; that is, in the opposite direction to the Konya Plain. This is not to say that Çatalhöyük did not enjoy some form of intermediary role

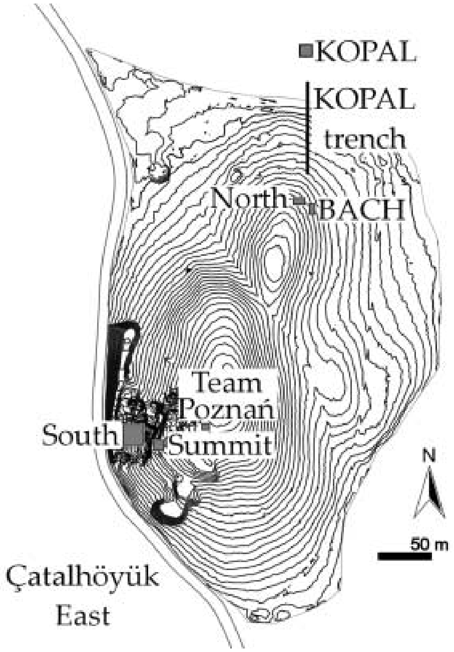

Figure 2 *A plan of Çatalhöyük East, showing the excavation areas mentioned in the text (Çatalhöyük Research Project).*

with the 'obsidian trade' (*sic*). It may have acted as a form of 'gateway community' (cf., Hirth 1978), with obsidian passing through the site *en route* to settlements in the Lake District and Antalya region, while some of its inhabitants may have acted as 'middlemen', or 'itinerant traders' (cf., Crawford 1978; Perlès 1990). With regard to Hasan Dağ, evidence suggests that the source was never used. Its obsidian is difficult to access and is a poor medium for tool production; moreover, numerous characterization studies have failed to link any archaeological obsidian to this mountain (Cauvin and Balkan-Atlı 1996, 252; Chataigner 1998, 292–3). In turn, there are many who now think the wall-painting depicts a leopard skin, rather than the volcano (Russell and Meece 2005, 212).

BACKGROUND TO THE STUDY

Obsidian characterization studies in Anatolia and South-West Asia have enjoyed a renaissance in the past decade (cf., Gomez *et al.* 1995; Gratuze 1999; Abbès *et al.* 2001; *inter alia*), many projects stemming from a recent major interdisciplinary study of Anatolia's numerous sources (Cauvin *et al.* 1998). Since 1999 this 'new wave' of sourcing studies has included a programme dedicated to investigating Çatalhöyük's history of obsidian consumption (Carter *et al.* 2005, 2006). This work involves laboratories in the UK, France and the USA, employing not only EDXRF, but also ICP–MS/–AES, LA–ICP–MS, PIXE and SEM–EDS (Table 1). Some 277 samples have been provenanced thus far, the artefacts coming from a range of contexts that span most of the site's occupation (Table 2). This paper details the elemental characterization of 42 obsidian artefacts from one part of the site, namely the BACH ('Berkeley Archaeologists at Çatalhöyük') trench. This excavation area contained a single Neolithic structure (Building 3),

Table 1 *The analysis of obsidian from Çatalhöyük: details of the laboratories, methods, number of samples and status of work*

Laboratory	*Method*	*Samples*	*Status*
Grenoble	ICP–MS/ICP–AES	100	Carter *et al.* (2005, 2006)
Aberystwyth	LA–ICP–MS	35	Carter *et al.* (2005, 2006)
Berkeley	EDXRF	42	This paper
Bordeaux	PIXE/SEM–EDS	100	Delerue *et al.* (in prep.)

Table 2 *Chronological distribution of the 277 obsidian artefacts characterized by Berkeley (n = 42), Aberystwyth (n = 35) and CNRS (n = 200)*

Mound	*Level*	*Samples*	*Area*	*Building*
West	E. Chalcolithic I–II	7	Trench I	25
East	III	12	South Summit	10
East	III–IV	1	4040	47
East	IV	9	South Summit	44
East	V–IV	10	4040	45
East	V	2	Summit	10
East	VIB	1	South	–
East	VII	15	South	?
East	VIII–VII	121	North/BACH	1, 3
East	VIII	16	South	?
East	IX–VIII	10	North	5
East	IX	15	South	2, 17
East	X	10	South	23
East	XII	5	South	–
East	Lower KOPAL	5	KOPAL	–
East	Pre-Level XII.A	8	South	–
East	Pre-Level XII.B	11	South	–
East	Pre-Level XII.C	11	South	–
East	Pre-Level XII.D	10	South	–

three abutting rooms of another building to the south and a narrow strip of external space to the west (Figs 2 and 3). The archaeology of the BACH trench has been dated to approximately halfway through the Neolithic sequence of the East Mound, *c*. Level VIII–VII (Table 2).

The larger obsidian sourcing project has a number of research agendas, not all of which will be dealt with here, as the data set under consideration comes from a single stratigraphic level. The first question to be asked of the BACH data concerns the origin of its raw materials and how they were being consumed. Technological and typological studies have detailed the rich and diverse nature of Çatalhöyük's obsidian assemblages through time (Conolly 1999a; Carter *et al*. 2005). While the tool types and knapping technologies may change, one thing remains constant—the fact that at any one time obsidian was being procured in a range of different forms and worked in various fashions. It is crucial to factor in these data when sampling; that is, to locate the study within a *chaîne opératoire* analytical framework (cf., Pelegrin *et al*. 1988) and to interrogate the relationship between raw material and specific knapping traditions,

Figure 3 *A plan of the BACH Area (Berkeley Archaeologists at Çatalhöyük): Building 3 to the north, the external midden to the west and Spaces 87–9 to the south (Berkeley Archaeologists at Çatalhöyük).*

rather than talk simply of sourcing 'obsidian'. For these reasons, each sample is described in detail and illustrated for publication alongside the results (Figs 5 and 6 below).

Another question that one can pose of the Building 3 material concerns the relationship between contemporary buildings and the obsidian sources (cf., Pires-Ferreira 1975, 31–5); that is, to what extent can it be assumed that the characterization data derived from one structure reflect what was occurring contemporaneously elsewhere on the site? Rights of access to a source may have been based on kinship affiliations or membership of some other corporate group (cf., Torrence 1986, 52–7; Shackley 2005, 134–71), with the result that different houses might contain different obsidians. We can start to approach this question through comparing the Building 3 data with those from its neighbour Building 1 (North Area; Fig. 2) as the two structures are considered to be broadly contemporary, at around Level VIII–VII (Cessford *et al.* 2005, 94). In undertaking this comparison, it should be noted that it remains uncertain as to what form(s) of social unit these buildings represent (Hodder 2005, 11–12).

The broad range of questions being asked by the sourcing programme necessarily involves the analysis of a large collection of samples; with the BACH material, some 277 pieces have now been analysed as part of the project (Table 2). This is a significantly larger data set than usually associated with a single site, following recent trends elsewhere, as with the *c.* 400 pieces from La Mana in Ecuador (Pereira 2000; Pereira *et al.* 2001), together with the hundreds from the Lower Ulúa Valley and Puerto Escondido in Honduras (Joyce *et al.* 2004) and pre-Classic and Classic sites in central Arizona (Shackley 2005, 136–71).

PREVIOUS OBSIDIAN CHARACTERIZATION STUDIES AT ÇATALHÖYÜK

Prior to this study, 255 artefacts from Çatalhöyük had been characterized over the past 40 years (Renfrew *et al.* 1966; Wright 1969; Keller and Seifried 1990; Carter *et al.* 2005, 2006). The results indicate that Çatalhöyük's obsidian came primarily from two sources in southern Cappadocia, East Göllü Dağ and Nenezi Dağ, 190 km north-east of the site and 10 km distant from one another (Fig. 1). The East Göllü Dağ 'source' actually subsumes more than one outcrop on the volcano. When the chemical field was first defined by Poidevin (1998, 115–21, fig. 9), it incorporated three geologically distinct flows spread over a few kilometres that could not be geochemically discriminated: Kayırlı-East, Kömürcü and Sirça Deresi (though see Gratuze 1999). Matters have since become more complicated, as new work on Göllü Dağ has documented 10 distinct outcrops that have been separated into four groups on the basis of geochemical, geochronological and structural analyses (Gratuze *et al.* 2005). This is a common pattern for silicic eruptive events. If there is constant and sufficient dome production, dome complexes are formed that can be quite extensive (Fink and Manley 1987; Griffiths and Fink 1993; Anderson *et al.* 1998; Fink and Anderson 2000). Depending on the level of fractionation or simply long-term dome production, individual events (outcrops here) may be similar or quite dissimilar chemically (Hildreth 1981; Mahood and Hildreth 1983; Mahood and Stimac 1990; Hughes and Smith 1993; Shackley 1998). Our research group is also working on the question of how to further deconstruct the East Göllü Dağ 'source', with initial results suggesting the *potential* ability to discriminate between the Kömürcü and East Kayırlı outcrops (Poupeau *et al.* 2005). In order to proceed further an expanded set of geological samples are required matching those discerned by Gratuze and his colleagues.

Aside from the East Göllü Dağ and Nenezi Dağ obsidians, there is also a handful of material from other sources. A flake from Building 1 (Level VII–VI) was provenanced to West Acıgöl in northern Cappadocia (Carter *et al.* 2006, 904), while three of the 1960s artefacts were also characterized as coming from this area (Renfrew *et al.* 1966, 38; though see Chataigner 1998, 285). Finally, another 1960s sample appeared to come from Transcaucasia—that is, hundreds of kilometres to the east—a result considered unlikely by the analysts, who suggested that it might *conceivably be an anomalous and exceptional product of a nearer source* (Renfrew *et al.* 1966, 33).

The recent characterization work has elucidated some clear trends in the data, not least a temporal distinction in how the two main raw materials were consumed. During the Aceramic Neolithic and the first half of the Neolithic sequence, the outcrops of East Göllü Dağ were the main sources exploited, the obsidians consumed in a number of distinct *chaînes opératoires*. These ranged from 'in house' low-skill production of small blades and blade-like flakes (attested in each building thus far excavated) to more specialist prismatic blade technologies (unipolar and bipolar), some of which may have been performed at quarry workshops (Carter *et al.* 2005, 2006; Carter in press a). Nenezi Dağ obsidian was a minority component of these early assemblages, represented almost exclusively by fine prismatic blades (unipolar and bipolar), which may also have been manufactured at the quarries (cf., Balkan-Atlı *et al.* 1999).

These modes of procurement and consumption changed radically approximately halfway through the Neolithic sequence (Level VIII–VII), with the mainstay 'in house' technology largely disappearing (along with the related importation of thick part-cortical 'quarry flakes'), to be replaced by unipolar pressure- and percussion-flaking blade technologies, a shift that coincided with a marked increase in the use of Nenezi Dağ obsidian (Conolly 1999b; Carter *et al.* 2006, 906–7). The organization of production also changed, with the skilled unipolar prismatic blade technologies—previously only represented as end-products—now performed on-site. This is a hugely significant change, with members of the community now being in possession of what was once a restricted (if not exotic) form of technical *savoir-faire*. Moreover, production shifts from house-by-house knapping to blade manufacture being located in the hands of a few, arguably a basis for new forms of social distinction at Çatalhöyük (Conolly 1999b).

THE BACH AREA AND ITS OBSIDIAN

The BACH trench is located on the East Mound's northern eminence, a part of the site first investigated in 1995 with the excavation of the Building 1/5 sequence in the nearby 'North' Area (Fig. 2). Excavated between 1997 and 2003, the BACH trench contained Building 3, together with three small rooms of another structure abutting to the south (spaces 87–9) and a narrow strip of external midden to the west (Fig. 3). Almost square in shape (6.36 m × 5.70 m), the archaeology of Building 3 is subdivided into five major phases, from construction and initial use (Phases 1.1–1.4), via episodes of remodelling and residence (Phases 2–3, 4A and 4B), to its demolition (Phase 5A) and post-Neolithic activities (Phase 5B). Architecturally, the structure is considered typical for Çatalhöyük in terms of its shape, size, mud-brick construction, the internal arrangement of its fixed features and the fact that it was entered through the roof by a ladder into the south-east corner. Throughout its history, the building's southern end was the focus of various 'domestic' activities, including food processing, cooking, and the production and use of certain obsidian tools. At Çatalhöyük this is described as a building's 'dirty' area, the floors being made up of artefact- and ash-rich soils (Hodder and Cessford 2004, 26–7); the western side was used for storage. Beyond this 'zone of transformative processes' was the much cleaner northern part of the structure (separated by a plaster ridge), its central floor surrounded by raised platforms of different heights (10–37 cm off the floor). During the building's life, a number of human burials were interred in this area. These are some of the only activities clearly ascertained in this part of the house, as the floors were kept meticulously clean, while all the original contents were typically removed prior to the structure's abandonment (cf., Cessford and Mitrović 2005, 53–8).

The BACH area generated 24 950 pieces of chipped stone, mainly obsidian (98.9%), plus various limnic-quartzites of unknown origin (Underbjerg *et al.* in prep.). Technologically, much of the obsidian relates to the aforementioned ‘in-house’ manufacture of irregular blades/blade-like flakes produced by a low-skilled percussive technology from opposed- or multi-platform cores. These simple and largely unmodified implements would have been used in everyday domestic activities such as food preparation. These tools were knapped from relatively large part-cortical flakes that were probably produced at the sources and are referred to generically as ‘quarry flakes’. These blanks, along with large biface preforms, seem to have entered the houses in small sack-loads, whose contents were then largely—if not entirely—buried as caches in the building’s ‘dirty area’ (Conolly 2003). The contents of these hoards would at some point—but not always—be retrieved, then worked *in situ* and/or exchanged with other members of the community (Carter *et al.* 2005, 238–40; Carter in press b). One such ‘quarry flake’ came from the fill under the entranceway floor, conceivably the remains of a larger cache (Underbjerg *et al.* in prep.).

The assemblage also included a few prismatic blades from a unipolar percussive technology. There were no cores or other forms of manufacturing debris associated with this technology, which suggested that the blades had been knapped elsewhere as part of a more specialized mode of production. The same situation has been documented in the other buildings of pre-Level VI.A date (Carter *et al.* 2005, 281–2). There were also a few projectiles, some no doubt representing the finished versions of the biface preforms, with quantities of thinning flakes found in the building’s ‘dirty area’. Other points were made on large prismatic blades (bigger than those mentioned above) for which we have no associated manufacturing debris; skilled products such as these may have come from quarry-based workshops (Balkan-Atlı *et al.* 1999).

THE SAMPLES AND THEIR CONTEXT

Forty-two obsidian artefacts were selected for provenance analysis, sampled in part to examine the perceived differences in raw material (colour, banding, translucency, inclusions and texture). Ideally, we would have wished to be able to discuss the relationship between raw material and technology in greater detail; however, most of the samples were inconspicuous flakes (selected for bureaucratic reasons), artefacts that cannot be assigned to a specific *chaîne opératoire*.

Of the artefacts from Building 3 proper, 12 were associated with the final phases of occupation—that is, B3.4A ($n = 9$) and B3.4B ($n = 3$)—while eight came from deposits relating to the structure’s dismantling and closure, B3.5 (Table 3). Five pieces derived from the post-occupation phase B3.6, two of which unfortunately came from the fill of a Roman burial (OB276, OB277); these artefacts are undoubtedly Neolithic and were almost certainly redeposited from the upper fill.

Table 3 *Distribution by phase and source of the 42 samples from the BACH area*

Context/phase	*Samples*	*East Göllü Dağ*	*Nenezi Dağ*
Building 3—Phase 4A	2	2	–
Building 3—Phase 4B	3	1	2
Building 3—Phase 5A	8	3	5
Building 3—Phase 5B	5	3	2
Midden (Space 85)	13	7	6
Space 89	3	2	1
Total	42	25 (59.5%)	17 (40.5%)

There is also one sample that is now known to have come from a surface deposit of uncertain date (OB267). These latter samples are far from perfect. While previous self-criticism focused on the need to have undertaken a full technological analysis of an assemblage prior to sampling, it is obviously equally important to possess a detailed post-excavation report so as to ensure the deposits' integrity. A further three samples were chosen from the small room due south of Building 3 (Space 89), while 13 artefacts came from the midden west of the structure (Space 85). These deposits are broadly contemporary with the house itself.

THE ANALYSES

All archaeological samples are analysed whole. The results presented here are quantitative (Table 4) in that they are derived from 'filtered' intensity values ratioed to the appropriate X-ray continuum regions through a least-squares fitting formula rather than plotting the proportions of the net intensities in a ternary system (Schamber 1977; McCarthy and Schamber 1981).

The trace element analyses were performed in the Archaeological XRF Laboratory, Department of Anthropology, University of California, Berkeley, using a Spectrace *QuanX* energy dispersive X-ray fluorescence spectrometer. The spectrometer is equipped with an air-cooled Cu X-ray target with a 125 µm Be window, an X-ray generator that operates from 4–50 kV/0.02–2.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTrace™ reduction software. The X-ray tube is operated at 30 kV, 0.14 mA, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 s livetime to generate X-ray intensity Kα-line data for elements titanium (Ti), manganese (Mn), iron (as Fe^T), zinc (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr) and niobium (Nb). Trace element intensities were converted to concentration estimates by employing a least-squares calibration line established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the US Geological Survey (USGS), the Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). Line fitting is linear (XML) for all elements except Fe, where a derivative fitting is used to improve the fit for the high concentrations of iron and thus for all the other elements. Further details concerning the petrological choice of these elements in obsidian are available in Shackley (1995, 1998, 2005; see also Mahood and Stimac 1990; Hughes and Smith 1993).

THE RESULTS

The data clearly indicate that we have two compositional groups, the larger group of 25 artefacts (59.5%) sourced to East Göllü Dağ and the remaining 17 pieces (40.5%) to Nenezi Dağ. The assignment to source was made by comparison with the compositional groups defined by Poidevin (1998), both with regard to major and trace elements using two-dimensional plotting (Fig. 4). With regard to colour, most of the samples described as 'translucent purple-grey' correlated with East Göllü Dağ obsidians, while those 'translucent with jet-black stripes' tended to be from Nenezi Dağ.

The East Göllü Dağ material

Aside from two unipolar prismatic blades (Fig. 5, 1 and 2), most of the 25 artefacts of East Göllü Dağ obsidian are small and rather undiagnostic non-cortical flakes (Fig. 5, 3–25). Much

Table 4 *Element contents determined by EDXRF for 42 samples from the BACH area*

Sample	*Ti*	*Mn*	*Fe*	*Zn*	*Ga*	*Th*	*Rb*	*Sr*	*Y*	*Zr*	*Nb*	*Nb/Zr*	*Y/Zr*	*Source*
OB251	1 349	513	10 725	47	16	36	181	104	16	141	26	0.180592	0.11007	Nenezi Dağ
OB252	1 349	556	11 009	48	13	28	179	109	12	137	15	0.110957	0.08549	Nenezi Dağ
OB253	1 367	639	10 330	44	20	22	220	31	20	77	22	0.285698	0.26123	East Göllü Dağ
OB254	1 028	449	7 835	30	11	26	184	20	19	77	36	0.46921	0.23974	East Göllü Dağ
OB255	1 242	483	9 144	41	16	33	204	17	27	78	23	0.288668	0.34027	East Göllü Dağ
OB256	1 598	668	13 711	71	23	22	205	117	26	148	14	0.09747	0.17787	Nenezi Dağ
OB257	1 200	402	9 603	36	14	40	189	29	15	89	32	0.365976	0.1728	East Göllü Dağ
OB258	1 064	501	9 118	31	22	26	201	27	27	87	22	0.257094	0.31598	East Göllü Dağ
OB259	1 078	545	10 163	43	19	26	209	32	19	88	25	0.286702	0.21953	East Göllü Dağ
OB260	1 051	486	8 850	31	19	43	203	24	23	83	23	0.279621	0.27621	East Göllü Dağ
OB261	1 344	525	11 164	59	16	25	172	107	18	131	25	0.188013	0.13589	Nenezi Dağ
OB262	1 285	448	10 310	48	14	33	166	105	23	133	24	0.183206	0.17241	Nenezi Dağ
OB263	1 067	507	8 729	28	15	33	201	26	27	84	18	0.217807	0.32493	East Göllü Dağ
OB264	1 080	523	8 514	31	15	9	194	28	22	77	15	0.200143	0.27987	East Göllü Dağ
OB265	1 323	625	12 079	55	18	38	188	114	27	140	18	0.131	0.19184	Nenezi Dağ
OB266	1 117	489	9 202	35	19	43	208	25	17	74	28	0.371922	0.22897	East Göllü Dağ
OB267	1 122	572	10 503	50	17	36	163	100	17	139	18	0.13262	0.1225	Nenezi Dağ
OB268	1 077	636	10 028	43	21	37	218	27	24	90	29	0.324349	0.26941	East Göllü Dağ
OB269	1 076	504	8 790	31	19	27	198	21	19	90	27	0.303582	0.21406	East Göllü Dağ
OB270	1 404	654	12 974	56	23	23	198	114	17	155	23	0.147928	0.1092	Nenezi Dağ
OB271	1 282	735	10 925	42	26	24	245	21	27	91	29	0.323232	0.29715	East Göllü Dağ
OB272	1 063	487	8 294	27	18	31	193	25	22	81	20	0.242515	0.2651	East Göllü Dağ
OB273	1 095	456	8 408	28	18	23	199	17	23	73	26	0.360204	0.30948	East Göllü Dağ
OB274	1 191	588	10 166	35	26	28	233	28	24	92	24	0.265158	0.25803	East Göllü Dağ
OB275	1 286	462	8 652	40	22	30	191	25	27	78	12	0.155027	0.34092	East Göllü Dağ
OB276	1 085	533	8 930	36	21	30	192	27	24	89	20	0.230132	0.26972	East Göllü Dağ
OB277	1 296	532	10 620	52	18	14	156	107	18	126	16	0.123298	0.13943	Nenezi Dağ
OB278	1 422	517	12 226	60	21	35	185	120	16	140	9	0.060914	0.11136	Nenezi Dağ
OB279	1 239	486	10 570	46	16	46	162	100	17	127	17	0.132717	0.1338	Nenezi Dağ
OB280	1 760	518	10 817	46	21	39	173	106	14	134	20	0.147069	0.1028	Nenezi Dağ
OB281	1 051	541	9 101	36	20	14	199	27	22	92	20	0.219241	0.23776	East Göllü Dağ
OB282	1 227	454	10 121	39	18	28	158	101	15	137	26	0.190345	0.1099	Nenezi Dağ
OB283	1 308	537	11 315	47	22	30	169	115	24	139	19	0.13415	0.16905	Nenezi Dağ
OB284	1 073	443	8 427	25	13	26	203	25	13	79	35	0.447202	0.16595	East Göllü Dağ
OB285	1 095	495	8 768	34	15	34	215	20	25	75	28	0.377343	0.32946	East Göllü Dağ
OB286	1 232	527	10 839	49	19	37	176	109	18	132	22	0.163681	0.13274	Nenezi Dağ
OB287	1 231	465	10 331	57	13	24	167	99	19	140	20	0.143965	0.13397	Nenezi Dağ
OB288	1 190	543	9 368	39	25	39	226	22	16	85	29	0.340193	0.19147	East Göllü Dağ
OB289	1 433	501	10 160	55	19	28	159	104	23	129	20	0.159036	0.17839	Nenezi Dağ
OB290	1 025	416	7 334	29	13	29	167	18	19	77	17	0.222825	0.24248	East Göllü Dağ
OB291	1 058	524	8 624	29	19	41	202	25	20	85	27	0.318913	0.24056	East Göllü Dağ
OB292	1 036	472	8 644	43	15	36	201	23	19	80	23	0.288346	0.24192	East Göllü Dağ
RGM1-H1	1 786	265	14 168	34	20	18	155	111	26	224	3	0.015631	0.11497	Standard
RGM1-H1	1 781	284	14 182	36	20	11	149	114	18	218	11	0.048404	0.08178	Standard
RGM1-H1	1 800	265	14 184	36	20	11	154	112	24	220	12	0.052615	0.10683	Standard
RGM1-H1	1 799	297	14 312	39	17	14	155	117	22	221	9	0.039035	0.1005	Standard

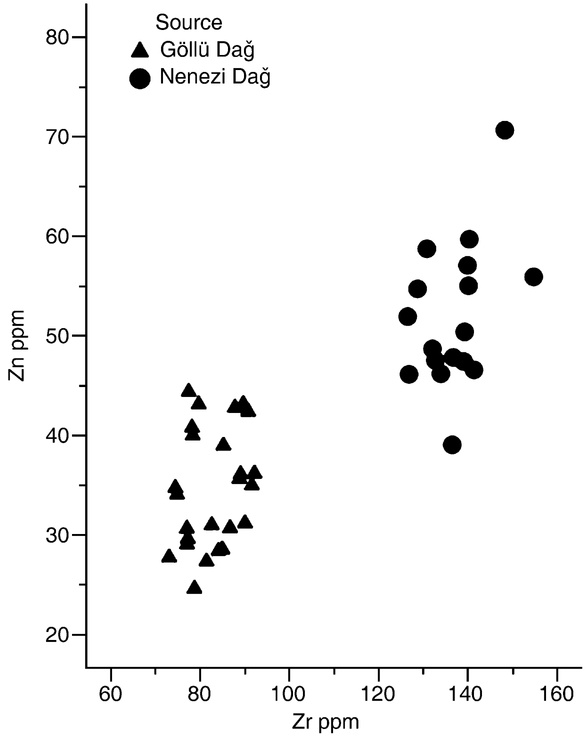

Figure 4 *A bivariate Zn–Zr diagram for 42 samples of obsidian using EDXRF.*

of this material likely relates to the mainstay ‘in-house’ low-skilled percussive bi-/multi-platform small blade and blade-like flake technology. Some of these pieces might also be thinning flakes from modifying projectile preforms. Excavation at the quarries (Kömürcü-East, Sector M) has revealed an area dedicated to the manufacture of the biface preforms; it has long been suggested that this was the workshop supplying Çatalhöyük (Cauvin and Balkan-Atlı 1996, 257, fig. 7:1). The Building 3 data—along with that generated previously from Building 1—provides good evidence that this was indeed the case. One final piece of note is OB257, a flake with cortex (Fig. 5, 3); cortical material is rare at Çatalhöyük and provides further evidence that East Göllü Dağ obsidian entered the building in the form of ‘quarry flakes’.

The Nenezi Dağ material

Three of the 17 pieces of obsidian sourced to Nenezi Dağ were in the form of unipolar prismatic blades (Fig. 6, 1–3). One was a proximal segment with flaked lip-removal (Fig. 6, 1), a characteristic trait of Çatalhöyük’s unipolar blade industries, particularly during the *latter* half of the Neolithic sequence (Carter *et al.* 2004). The other artefacts include an exhausted bipolar core from the ‘in-house’ percussive technology (Fig. 6, 4), and a series of relatively undiagnostic flakes that probably relate to the same production strategy (Fig. 6, 5–16). Once again, it is not inconceivable that some of these latter blanks are thinning flakes from biface preforms.

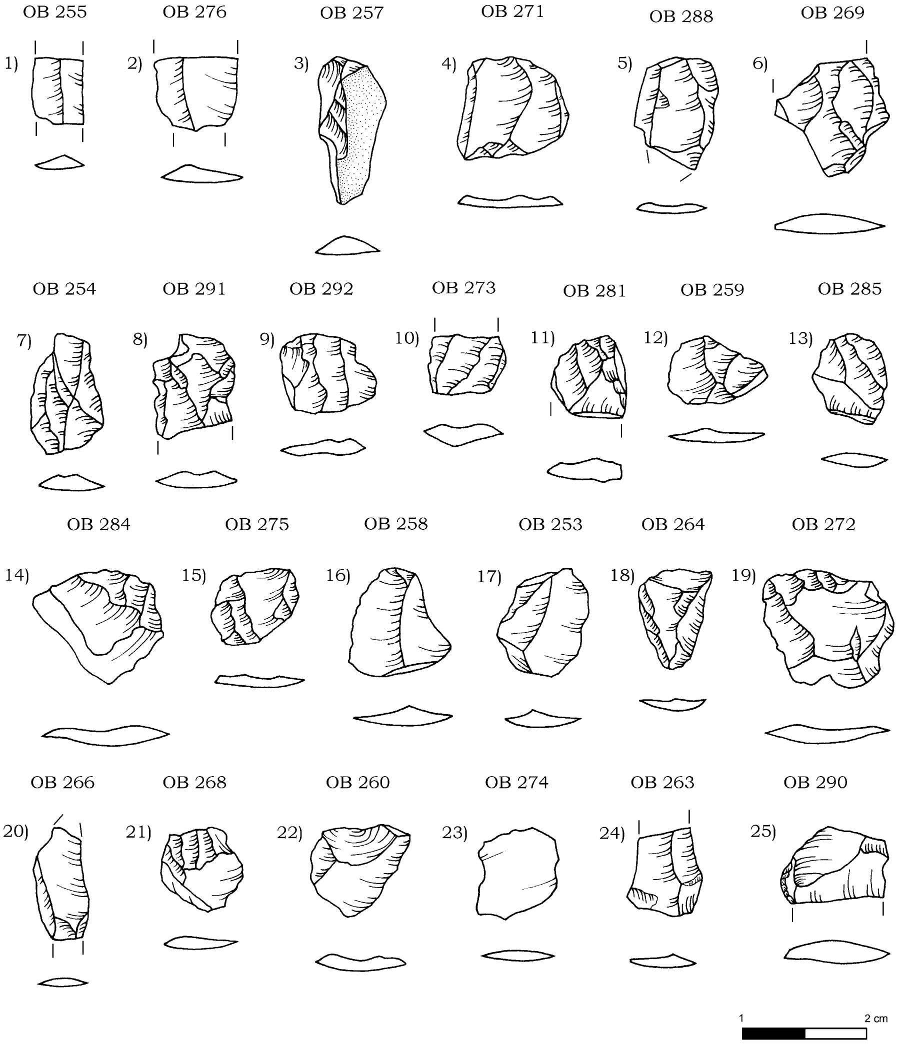

Figure 5 *Obsidian artefacts sourced by EDXRF to East Göllü Dağ (M. Milić).*

THE DATA IN ITS BROADER CONTEXT

Çatalhöyük's exploitation of these southern Cappadocian raw materials did not occur in isolation, with East Göllü Dağ and Nenezi Dağ obsidians being consumed in tandem at many other Neolithic sites in central Anatolia and beyond (Fig. 1). In 'local' terms, the Building 3 assemblage dates to Early Central Anatolian IIIB (Özbaşaran and Buitenhuis 2002), and Period 5 in the broader Near Eastern terminology of the Maison de l'Orient (Hours *et al.* 1994), approximately 7000–6300 BC. East Göllü Dağ obsidian is recorded from Ilicapinar north of the Konya Plain, Mersin on the Cilician coast, plus a number of sites in Cyprus, the Middle Euphrates and Levant (Chataigner 1998, 285–92, fig. 7a–b). Nenezi Dağ obsidian is less well

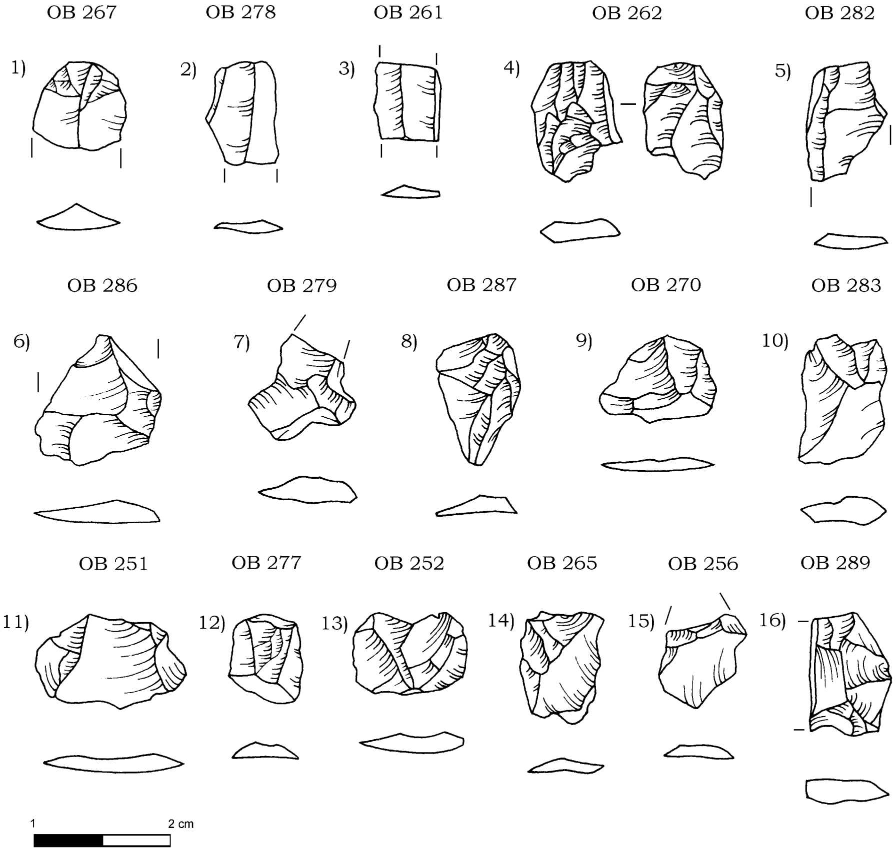

Figure 6 *Obsidian artefacts sourced by EDXRF to Nenezi Dağ (M. Milić).*

attested, being recorded from only a few of these sites, including Halula in the Middle Euphrates, Byblos on the Levantine coast and Mevrokah in the southern Levant; it is also the one obsidian currently represented at Tarsus in Cilicia (Chataigner 1998, 285, fig. 5a–b). Unfortunately, the literature provides little insight as to the form in which these communities procured their obsidian. The Çatalhöyük data thus make an important contribution on this front.

DISCUSSION

Given the results of the previous characterization studies at Çatalhöyük, it came as no surprise that the Building 3 artefacts were made from East Göllü Dağ and Nenezi Dağ obsidians. The relative proportions of the 'two' raw materials and the artefacts' technological specifics are another matter. In contextualizing the Building 3 results (Fig. 7), we compare the data with those from the North Area's Building 1 (with 79 samples), its nearest neighbour in time and space (Fig. 2). In terms of comparability, both data sets contained material from the 'in-house' blade/blade-like flake technology and 'quarry flakes' made from East Göllü Dağ obsidians, as well as unipolar prismatic blades made from both of the raw materials. The one major difference is that the Building 3 samples include knapping debris of Nenezi Dağ obsidian, whereas

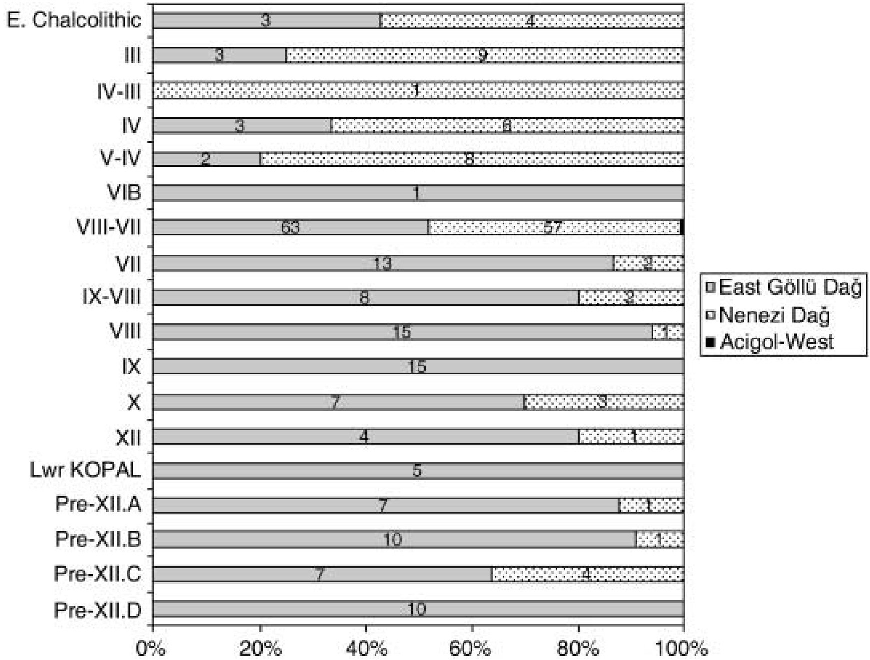

Figure 7 *The 277 obsidian artefacts analysed by Berkeley (n = 42), Aberystwyth (n = 35) and CNRS (n = 200): by source and stratigraphic level (one sample from Acıgöl-West, Level VIII–VII).*

the Building 1 artefacts of this material were comprised mainly of end-products (Carter *et al.* 2005, 293–4, figs 12.5c–12.5f). This difference is of some significance, a tantalizing *hint* of differential practices in these two structures.

With regard to the relative proportions of the raw materials, the two data sets are quite similar, with Building 3's *c*. 60:40 ratio between East Göllü Dağ and Nenezi Dağ obsidians, compared to Building 1's *c*. 50:50. Taking a long-term perspective, it can be seen that these two structures existed at that time when Nenezi Dağ obsidian was enjoying a marked increase in consumption (Fig. 7). For instance, Building 5 (Level IX–VIII), the structure stratified beneath Building 1, has an 80:20 ratio between East Göllü Dağ and Nenezi Dağ obsidians (admittedly only 10 samples).

Previously, it was claimed that the shift to a greater reliance upon Nenezi Dağ obsidian was a relatively rapid phenomenon (within one or two generations) and related integrally to unipolar prismatic blade technologies becoming the dominant mode of consuming obsidian at the site (Carter *et al.* 2006). This interpretation has to be critically appraised as new archaeometric data are generated. Charting the rate of change over time and the relationship between the shifts in raw material and technology are not unproblematic tasks due to some of the issues surrounding Çatalhöyük's chronological sequence. The first problem relates to presenting the data on a neatly tabulated level-by-level basis, as if entire horizons of buildings were laid down overnight, whereas the reality is far more organic, with structures being abandoned and built anew. Secondly, the sourcing data are derived from three parts of the site that have yet to be physically linked to one another. The South Area (including the 'South Summit') is the largest area exposed and has the greatest stratigraphic depth, from Level III to the mound's base (Level Pre-XII.D). The much smaller North and BACH areas are both floating short-term sequences, while the site's other trenches—4040, TP and IST—are similarly isolated stratigraphies of limited depth (Fig. 2). Until quite recently, the archaeology of these discrete areas was linked through recourse to artefact style and technology, the notion being that certain types of chipped stone and pottery were diagnostic of a specific period/stratigraphic level (Conolly 1999a; Carter *et al.* 2005; Last 2005). Some of these assumptions have been challenged by the new radiocarbon dates (Cessford *et al.* 2005). For instance, Building 1's material culture looked younger than it was; that is, while the pottery and lithics were dated to Level VI (Conolly 1999b; Last 2005, 102), the carbon-14 dates assigned the structure to Levels VIII–VII (Cessford *et al.* 2005, 88). The implications of these new dates are very interesting, as here there may be evidence that the changes in modes of procuring and working obsidian were not felt throughout the entire community at once. Instead, there may have been community 'hot spots'—such as this northern eminence—where prismatic blade technologies were first performed (and/or the introduction of those people wielding the technical know-how), while the rest of the population lagged behind (Carter *et al.* 2004). This interpretation represents a working hypothesis, as much remains to be resolved with regard to Çatalhöyük's intra-site chronology.

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REFERENCES

Abbès, F., Bellot-Gurlet, L., Bressy, C., Cauvin, M.-C., Gratzue, B., and Poupeau, G., 2001, Nouvelles recherches sur l'obsidienne de Cheikh Hasan (Vallée de l'Euphrate, Syrie) au Néolithique PPNA et PPNB, *Syria*, **78**, 1–13.

Anderson, S. W., Stofan, E. R., Plant, J. J., and Crown, D. A., 1998, Block size distributions on silicic lava flow surfaces: implications for emplacement conditions, *Geological Society of America Bulletin*, **110**, 1258–67.

Balkan-Atlı, N., Binder, D., and Cauvin, M.-C., 1999, Obsidian: sources, workshops and trade in central Anatolia, in *Neolithic in Turkey: the cradle of civilization. New discoveries* (eds. M. Özdoğan and N. Başgelen), 133–45, Arkeoloji ve Sanat Yayınları, Istanbul.

Carter, T., in press a, New obsidian studies at Çatalhöyük, part I: the Aceramic Neolithic data, *Paléorient*.

Carter, T., in press b, Of blanks and burials: hoarding obsidian at Neolithic Çatalhöyük, in *PPN communities' technical system diversity: towards social behavior. Proceedings of the Fifth Workshop on PPN Chipped Lithic Industries. Fréjus, 2004* (eds. L. Astruc, D. Binder and F. Briois), Éditions APDCA, Antibes.

Carter, T., Conolly, J., and Spasojević, A., 2005, The chipped stone, in *Changing materialities at Çatalhöyük: reports from the 1995–1999 seasons* (ed. I. Hodder), 221–83 and 467–533, McDonald Institute Monographs and BIAA, Cambridge.

Carter, T., Delerue, S., and Milić, M., 2004, Chipped stone report, in *Çatalhöyük 2004 Archive Report*; http://catal.arch.cam.ac.uk/catal/Archive_rep04/ar04_27.html

Carter, T., Poupeau, G., Bressy, C., and Pearce, N. J. P., 2005, From chemistry to consumption: towards a history of obsidian use at Çatalhöyük through a programme of inter-laboratory trace-elemental characterization, in *Changing materialities at Çatalhöyük: reports from the 1995–1999 seasons* (ed. I. Hodder), 285–305 and 535–57, McDonald Institute Monographs and BIAA, Cambridge.

Carter, T., Poupeau, G., Bressy, C., and Pearce, N. J. P., 2006, A new programme of obsidian characterization at Çatalhöyük, Turkey, *Journal of Archaeological Science*, **33**(7), 893–909.

Cauvin, M.-C., and Balkan-Atlı, N., 1996, Rapport sur les recherches sur l'obsidienne en Cappadoce, 1993–1995, *Anatolica Antiqua*, **IV**, 249–71.

Cauvin, M.-C., and Chataigner, C., 1998, Distribution de l'obsidienne dans les sites archéologiques du Proche et Moyen Orient, in *L'Obsidienne au Proche et Moyen Orient: du volcan à l'outil* (eds. M.-C. Cauvin, A. Gourgaud, B. Gratauze, N. Arnaud, G. Poupeau, J.-L. Poidevin and C. Chataigner), 325–50, Maison de l'Orient Méditerranéen, BAR International Series **738**, Archaeopress, Oxford.

Cauvin, M.-C., Gourgaud, A., Gratauze, B., Arnaud, N., Poupeau, P., Poidevin, J.-L., and Chataigner, C., 1998, *L'Obsidienne au Proche et Moyen Orient: du volcan à l'outil*, Maison de l'Orient Méditerranéen, BAR International Series **738**, Archaeopress, Oxford.

Cessford, C., 2005, Estimating the Neolithic population of Çatalhöyük, in *Inhabiting Çatalhöyük: reports from the 1995–1999 seasons* (ed. I. Hodder), 323–6, McDonald Institute Monographs and BIAA, Cambridge.

Cessford, C., with contributions from S. Mitrović, 2005, Heavy-residue analysis, in *Changing materialities at Çatalhöyük: reports from the 1995–1999 seasons* (ed. I. Hodder), 45–63, McDonald Institute Monographs and BIAA, Cambridge.

Cessford, C., with contributions from P. Blumbach, K. Göze Akoğlu, T. Higham, P. I. Kuniholm, S. W. Manning, N. W. Newton, M. Özbakan and A. Melek Özer, 2005, Absolute dating at Çatalhöyük, in *Changing materialities at Çatalhöyük: reports from the 1995–1999 seasons* (ed. I. Hodder), 65–99 and 449–50, McDonald Institute Monographs and BIAA, Cambridge.

Chataigner, C., 1998, Sources des artefacts néolithiques, in *L'Obsidienne au Proche et Moyen Orient: du volcan à l'outil* (eds. M.-C. Cauvin, A. Gourgaud, B. Gratauze, N. Arnaud, G. Poupeau, J.-L. Poidevin and C. Chataigner), 273–324, Maison de l'Orient Méditerranéen, BAR International Series **738**, Archaeopress, Oxford.

Conolly, J., 1999a, *The Çatalhöyük flint and obsidian industry. Technology and typology in context*, BAR International Series **787**, Archaeopress, Oxford.

Conolly, J., 1999b, Technical strategies and technical change at Neolithic Çatalhöyük, Turkey, *Antiquity*, **73**, 791–800.

Conolly, J., 2003, The Çatalhöyük obsidian hoards: a contextual analysis of technology, in *Lithic studies for the new millennium* (eds. N. Moloney and M. Shott), 55–78, Archtype, London.

Crawford, H., 1978, The mechanics of obsidian trade: a suggestion, *Antiquity*, **52**, 129–32.

Delerue, S., Poupeau, G., Carter, T., Le Bourdonnec, F.-X., Dubernet, S., Calligaro, T., and Moretto, P., in prep., The use of PIXE and SEM–EDS for obsidian provenance studies in the Near East: a case study from Neolithic Çatalhöyük (central Anatolia), *Journal of Archaeological Science*.

Fairburn, A., Asouti, E., Near, J., and Martinoli, D., 2002, Macro-botanical evidence for plant use at Neolithic Çatalhöyük, south-central Anatolia, Turkey, *Vegetation History and Archaeobotany*, **11**, 41–54.

Fink, J. H., and Anderson, S. W., 2000, Lava domes and coulees, in *Encyclopedia of Volcanoes* (ed. H. Sigurdsson), 307–20, Academic Press, San Diego.

Fink, J. H., and Manley, C. R., 1987, Origin of pumiceous and glassy textures in rhyolite flows and domes, in *The Emplacement of Silicic Domes and Lava Flows* (ed. J. H. Fink), 77–88, Special Paper 212, Geological Society of America, Boulder, CO.

Gomez, B., Glascock, M. D., Blackman, J., and Todd, I. A., 1995, Neutron activation analysis of obsidian from Kalavasos-*Tenta*, *Journal of Field Archaeology*, **22**(4), 503–8.

Govindaraju, K., 1994, 1994 Compilation of working values and sample description for 383 geostandards, *Geostandards Newsletter*, **18**, 1–158.

Gratuze, B., 1999, Obsidian characterization by laser ablation ICP–MS and its application to prehistoric trade in the Mediterranean and the Near East: sources and distribution of obsidian with the Aegean and Anatolia, *Journal of Archaeological Science*, **26**(10), 869–81.

Gratuze, B., Boucetta, S., Binder, D., Balkan-Atlı, N., Bellot-Gurlet, L., and Mouralis, D., 2005, New investigations of the Göllü Dağ obsidian lava flows system: comparison between chemical, mineralogical and fission track data, *International Association of Obsidian Studies*, **33**, 18–19.

Griffiths, R. W., and Fink, J. H., 1993, Effect of surface cooling on the spreading of lava flows and domes, *Journal of Field Mechanics*, **252**, 667–702.

Hildreth, W., 1981, Gradients in silicic magma chambers: implications for lithospheric magmatism, *Journal of Geophysical Research*, **86**, 10 153–92.

Hirth, K. G., 1978, Inter-regional trade and the formation of prehistoric gateway communities, *American Antiquity*, **43**, 25–45.

Hodder, I., 2005, Introduction, in *Çatalhöyük perspectives: themes from the 1995–9 seasons* (ed. I. Hodder), 1–14, McDonald Institute Monographs and BIAA, Cambridge.

Hodder, I., and Cessford, C., 2004, Daily practice and social memory at Çatalhöyük, *American Antiquity*, **69**(1), 17–40.

Hours, F., Aurenche, O., Cauvin, J., Cauvin, M.-C., Copeland, L., and Sanlaville, P., 1994, *Atlas des sites du Proche Orient (14 000–5700 BP)*, Travaux de la Maison de l'Orient, Lyon.

Hughes, R. E., and Smith, R. L., 1993, Archaeology, geology, and geochemistry in obsidian provenance studies, in *Scale on archaeological and geoscientific perspectives* (eds. J. K. Stein and A. R. Linse), 79–91, Special Paper 283, Geological Society of America, Boulder, CO.

Joyce, R. A., Shackley, M. S., McCandless, K., and Sheptak, R., 2004, Resultados preliminares de una investigación con EDXRF de obsidiana de Puerto Escondido, in *Yaxkin: Memoria, VII Seminario de Antropología de Honduras 'Dr. George Hasemann'*, 115–30, Instituto Hondureño de Antropología e Historia, Honduras.

Keller, J., and Seifried, C., 1990, The present state of obsidian source identification in Anatolia and the Near East, in *Volcanologie et Archéologie* (eds. C. Albore Livadie and F. Wideman), 58–87, PACT 25, Conseil de l'Europe, Strasbourg.

Last, J., 2005, Pottery from the East Mound, in *Changing Materialities at Çatalhöyük: reports from the 1995–1999 seasons* (ed. I. Hodder), 101–38, McDonald Institute Monographs and BIAA, Cambridge.

Mahood, G., and Hildreth, W., 1983, Large partition coefficients for trace elements in high-silica rhyolites, *Geochimica et Cosmochimica Acta*, **47**, 11–30.

Mahood, G., and Stimac, J. A., 1990, Trace-element partitioning in pantellerites and trachytes, *Geochimica et Cosmochimica Acta*, **54**, 2257–76.

McCarthy, J. J., and Schamber, F. H., 1981, Least-squares fit with digital filter: a status report, in *Energy dispersive X-ray spectrometry* (eds. K. F. J. Heinrich, D. E. Newbury, R. L. Myklebust and C. E. Fiori), 273–96, Special Publication 604, National Bureau of Standards, Washington, DC.

Mellaart, J., 1967, *Çatal Hüyük: a Neolithic town in Anatolia*, Thames and Hudson, London.

Özbaşaran, M., and Buitenhuis, H., 2002, Proposal for a regional terminology for central Anatolia, in *The Neolithic of Central Anatolia: internal developments and external relations during the 9th–6th millennia cal BC* (eds. F. Gérard and L. Thissen), 67–77, Eye Yayinlari, Istanbul.

Pelegrin, J., Karlin, C., and Bodu, P., 1988, 'Chaînes opératoires': un outil pour le préhistorien, in *Technologie préhistorique* (ed. J. Tixier), 55–62, Notes et Monographies Techniques du CRA 25, Paris, CNRS.

Pereira, C. E. de B., 2000, *Otimização de metodologias para a análise multiementar de obsidianas por ICP–MS com Amostragem por ablação a laser e aplicações em estudos de proveniência de artefactos arqueológicos*, unpublished Ph.D. thesis, PUC-Rio.

Pereira, C. E. de B., Miekeley, N., Poupeau, G., and Küchler, I. L., 2001, Determination of minor and trace elements in obsidian rock samples and archaeological artefacts by laser ablation inductively coupled plasma mass spectrometry using synthetic obsidian standards, *Spectrochimica Acta Part B*, **56**, 1927–40.

Perlès, C., 1990, L'outillage de pierre taillée Néolithique en Grèce: approvisionnement et exploitation des matières premières, *Bulletin de Correspondance Hellénique*, **CXIV**, 1–42.

Pires-Ferreira, J. W., 1975, *Formative Mesoamerican exchange networks with special reference to the Valley of Oaxaca*, Memoirs of the Museum of Anthropology, No. 7. University of Michigan, Ann Arbor.

Poidevin, J.-L., 1998, Les gisements d'obsidienne de Turquie et de Transcaucasie: géologie, géochemie et chronométrie, in *L'Obsidienne au Proche et Moyen Orient: du volcan à l'outil* (eds. M.-C. Cauvin, A. Gourgaud, B. Gratauze, N. Arnaud, G. Poupeau, J.-L. Poidevin and C. Chataigner), 105–203, Maison de l'Orient Méditerranéen, BAR International Series **738**, Archaeopress, Oxford.

Poupeau, G., Delerue, S., Carter, T., de B. Pereira, C. E., Miekeley, N., and Bellot-Gurlet, L., 2005, How homogeneous is the 'East Göllü Dağ' (Cappadocia Turkey) obsidian 'source' composition?, *International Association of Obsidian Studies Bulletin*, **32**, 3–8.

Renfrew, C., Dixon, J. E., and Cann, J. R., 1966, Obsidian and early culture contact in the Near East, *Proceedings of the Prehistoric Society*, **XXXII**, 30–72.

Russell, N., and Meece, S., 2005, Animal representations and animal remains at Çatalhöyük, in *Çatalhöyük perspectives: themes from the 1995–9 seasons* (ed. I. Hodder), 209–30, McDonald Institute Monographs and BIAA, Cambridge.

Schamber, F. H., 1977, A modification of the linear least-squares fitting method which provides continuum suppression, in *X-ray fluorescence analysis of environmental samples* (ed. T. G. Dzubay), 241–57, Ann Arbor Science Publishers, Ann Arbor.

Shackley, M. S., 1995, Sources of archaeological obsidian in the Greater American Southwest: an update and quantitative analysis, *American Antiquity*, **60**, 531–51.

Shackley, M. S., 1998, Geochemical differentiation and prehistoric procurement of obsidian in the Mount Taylor Volcanic Field, northwest New Mexico, *Journal of Archaeological Science*, **25**, 1073–82.

Shackley, M. S., 2005, *Obsidian: geology and archaeology in the North American Southwest*, University of Arizona Press, Tucson.

Torrence, R., 1986, *Production and exchange of stone tools*, Cambridge University Press, Cambridge.

Underbjerg, H. M., Carter, T., and Shackley, M. S., in prep., The flaked stone assemblage from Building 3 (analysis from the BACH area), in *The last house on the mound* (eds. R. Tringham and M. Stevanović), Mounumenta Archaeologica, Cotsen Institute of Archaeology, University of California, Los Angeles.

Wright, G. A., 1969, *Obsidian analyses and prehistoric Near Eastern Trade: 7500 to 3500 BC*, Anthropological Papers No. 37, Museum of Anthropology, University of Michigan, Ann Arbor.