The growth of early social networks: New geochemical results of obsidian from the Ubaid to Chalcolithic Period in Syria, Iraq and the Gulf

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Abstract:

Obsidian artifacts are geochemically traceable to their geological sources of origin. The results of their analysis provide some of the most accurate testimonies of interaction, exchange and population movement. This article presents results of obsidian analyses of artifacts from twelve sites from the Middle Euphrates to the Arabian Gulf. We demonstrate that the Sıcaksu flow of Nemrut Dağ in eastern Turkey consistently supplied obsidian to the majority of sites across this region from the 7th to 4th millennia BC. This outcrop predominated in analyzed assemblages and as a production material for the region, across all site positions, sizes and periods; this has been argued to be a result of the quality, quantity and accessibility of this flow (Robin et al. [this volume](#)). The analyses demonstrate the presence of mainly finished products from a variety of additional sources in eastern Anatolia and Armenia (average > 4 sources) on northern Mesopotamian sites during this time span. We argue that the Nemrut region was a major economic node and chief actor in the establishment and dynamics of networks in the greater region. The diachronic persistence or breaks in obsidian supply from more minor sources are an additional source of information on the inner workings and development of subtle interregional socio-political and economic relations. Obsidian analysis provides a detailed picture of the contributions of increasingly complex networks and channels of communication to intensified adoption of common practices and styles across regions, to intensification of processes leading to urbanization and state formation, and to accentuating periods of stress and conflict. These data nourish and update existing models on social networks during the crucial Ubaid to Late Chalcolithic periods and advance debates on the role and impact of these networks on early state formation.

Highlights:

- We analyze 168 samples of archaeological obsidian from 12 Halaf to LC3 period sites in Mesopotamia and the Arabian Gulf using LA-HR-ICP-MS
- We demonstrate that these sites match a great number of sources in eastern Anatolia and Armenia and that varieties increase in the Ubaid and LC2 periods
- Overall matches show a preponderance of obsidian from the newly studied Sıcaksu outcrop of Nemrut Dağ across periods and regions treated
- The data suggests that the Nemrut region was a major economic actor in complex networks of interaction that were essential to the trajectories of pre-state societies in the ancient Near East

Keywords: Mesopotamia; Arabian Gulf; Ubaid; Chalcolithic; obsidian provenance; LA-HR-ICP-MS; social networks

1. Introduction

Research on the dynamics and modelling of early interaction spheres is increasingly valuable in explaining socio-economic transformations. Within such modelling, developments in methods of geological sampling and obsidian fingerprinting allow us to look beyond simple formulations of raw material exploitation (Robin et al., [this volume](#)) and its distribution (Ortega et al 2014) to include potential factors that may have had an impact on the configuration and functioning of social networks (Ibañez et al 2015).

In this paper, we evoke new data on obsidian source distinctions treated in more detail in Robin et al. ([this volume](#)) and discuss these in relation to recent Laser Ablation Inductively

Coupled Plasma Mass Spectrometry (LA-ICP-MS) analyses of archaeological obsidian recovered from Halaf/Ubaid to Late Chalcolithic period (6th-4th mill BC) sites in Syria (Khirbat al-Fakhar, Tell Brak/Tell Majnuna, Tell Zeidan), Iraq (Kheit Qassim, Khirbet Derek, Umm Dabaghiyah, and Arpachiyah), Iraqi Kurdistan (Surezha) and the Arabian Gulf (as-Sabiyah, Dosariyah, Wadi Debay'an) (Fig. 1). We focus mainly on new data from the northern Mesopotamian sites of Tell Zeidan (Halaf-Ubaid to LC2), Surezha (LC1-LC3), Khirbat al-Fakhar (LC1-LC2) and Tell Brak/ Tell Majnuna (LC2-LC3). We then compare these to new obsidian data from sites in northern Iraq and the Arabian Gulf. We discuss implications of these results for our understanding of the development of long-distance interaction spheres in the region on a diachronic scale that spans the crucial period between the onset of the Neolithic and the beginnings of state formation.

Obsidian geological sources: 1. Chikiani; 2. Artani; 3. Ashotsk; 4. Gegham; 5. Gutansar; 6. Hatis; 7. Kecheldag; 8. Khorapor; 9. Syunik; 10. Tsaghkunyats; 11. Tendürek; 12. Süphan Dağ; 13. Nemrut Dağ; 14. Müş; 15. Meydan; 16. Bingöl-Solhan; 17. Bingöl-Alatepe; 18. Erzincan; 19. Erzurum; 20. İkizdere; 21. Kars-Diggor; 22. Kars-Arpaçay; 23. Sankamış; 24. Pasinler; 25. Erciyes; 26. Acıgöl; 27. Göllüdağ; 28. Nenezidağ; 29. Hasandağ.

Archaeological sites: **a. Wadi Debay'an (QNHER 141); b. Dosariyah; c. As-Sabiyah; d. Uruk / Warka; e. Tell Oueili; f. Al 'Ubaid; g. Eridu; h. Choga Mami; i. Kheit Qasim; j. Surezha; k. Khirbet Derek; l. Arpachiyah; m. Tepe Gawra; n. Umm Dabaghiyah; o. Tell Brak / Tell Majnuna; p. Tell Hamoukar / Khirbat al Fakhar; q. Tell Zeidan; r. Chagar Bazar; s. Khaznah; t. Hammam et Turkman; u. Kosak Shamali; v. Domuztepe; w. Hacinebi; x. Arslantepe.**

In bold, archaeological sites with obsidian artifacts studied in this paper

Fig. 1

Formalized prehistoric interaction networks in the Near East are documented from as early as the Pre-pottery Neolithic A (PPNA; 10000 - 8500 BC), and their growth and impact was increasingly visible thereafter. During the Pre-Pottery Neolithic B (PPNB; 8500 - 7000 BC), social hierarchies develop in tandem with increasingly complex social networks, affecting the reach of cultural expressions and material goods, and encouraging genetic intermixing between regions (Ibañez et al. 2015). PPNB networks traversed most of the Fertile Crescent, and comparable lithic technologies such as the naviform technique can be found in the southern Levant (Khalidi et al. 2013; Burian et al. 1999) and northern reaches of Arabia (Crassard and Khalidi in press). During the early Neolithic, the source of Göllüdağ among others in central Anatolia prominently featured in obsidian assemblages but were more or less restricted to central Anatolia and the Levant, rarely supplying sites east of the middle Euphrates, while eastern Anatolian obsidian was present in smaller quantities throughout the entire region.

During the Ubaid period (6500-4200 BC), the southern Mesopotamian ceramic style expanded, reaching the Arabian Gulf, parts of the Caucasus and Anatolia, and Mediterranean shores (Carter and Philip 2010: 1). The Ubaid, like the Middle/Late Uruk (LC4-5), is one peak of southern Mesopotamian influence on surrounding regions, namely on northern Mesopotamia and eastern Anatolia. However, it is now largely accepted that symbiotic relationships formed between regions during this period that were not simply limited to unidirectional influence or to a single dominant political economy, but rather to coexisting regional economies and social identities (Stein 2012: 126; 2010: 25). As a result, the Ubaid spread is commonly referred to as a phenomenon, an ‘interaction sphere’ and a ‘horizon style’ (Carter and Philip 2010; Stein 2010) to describe observed cultural similarities over long distances and millennia. Coinciding with this expanding cultural sphere, eastern Anatolian obsidian can be found across the Fertile Crescent, and its supply networks overlap over much of the region that had been previously dominantly supplied by central Anatolian sources.

The early Ubaid is mainly known from southern Mesopotamian sites such as Ur, Eridu, and Tell al-Ubaid, while sites like Arpachiyah in northern Mesopotamia were characterized by a local Halaf culture. By the Ubaid 2/3, southern Mesopotamian Ubaid ceramics are found amid a local Neolithic culture in the Arabian Gulf (5500-5000 BC), at sites such as as-Sabiyah (H3) in Kuwait (Carter 2006) and Dosariyah in eastern Saudi Arabia (Masry 1997). The “Northern Ubaid” or Ubaid 3/4 (5300-4500 BC), which overlaps with the Gulf Ubaid for about three centuries, is characterized by the spread of late Ubaid material culture into existing distinct local polities in Upper Mesopotamia and eastern Anatolia and can be found at sites such as Tell Zeidan, Kosak Shamali, and Tepe Gawra.

The Late Chalcolithic period (LC1-5 or 4200-3100 BC, northern Mesopotamian regional chronology) that followed also comprises a number of developmental trajectories that vary depending on region and specific site. The LC1-3 periods witness developing forms of social complexity in the form of large public buildings (McMahon et al. 2007), organized administrative systems and specialized production of utilitarian and prestige goods (Al Kuntar and Abu Jayyab 2014; Khalidi 2014; Stein 2012) as well as unprecedented settlement growth at proto-urban scales and formalized site hierarchy (Adams 1981; Algaze 2008; Al-Kuntar et al. 2011; McMahon and Stone 2013; Ur et al 2007; Wilkinson and Tucker 1995; Wright 2001) and what has been interpreted as the beginnings of organized warfare (McMahon et al. 2011).

This contribution together with that of Robin et al. ([this volume](#)), discusses issues in Near Eastern obsidian studies, including the increasing inter- and intra-source distinction of the peralkaline sources of eastern Anatolia and the increasing archaeological visibility of the '3D' source. Through multidisciplinary research, Robin et al. ([this volume](#)) propose that the Sıcaksu flow of Nemrut Dağ was preferred by populations from eastern Anatolia to the Persian Gulf and the southern Levant from the PPNB until at least the 3rd millennium BC. The data presented here demonstrate the overwhelming importance of Nemrut Dağ as a source and hub of economic activity across periods and regions. The identification of the major obsidian locale of Sıcaksu provides a plethora of possibilities for future research regarding the reasoning underlying human choice (individual or group-led) among resources of equal accessibility and how those choices were distorted or reinstated through time. The data also provide a window into the waxing and waning in importance of more distant sources, allowing comprehensive discussion on developing political and economic relations of Mesopotamian sites with eastern Anatolia and the Caucasus.

2. Previous research and current trends

2.1 Introduction to previous obsidian research

Since the 60s and 70s when Renfrew, Dixon and Cann ([Cann and Renfrew 1964](#); [Renfrew, Dixon and Cann 1966](#); [1968](#); [Renfrew and Dixon 1976](#)) published their seminal papers on obsidian exchange, the peralkaline obsidian sources of eastern Anatolia have been the source of ambiguous artifact to source attribution as a result of similarities in chemical fingerprints of available source data. At the time, Renfrew and authors had identified a number of obsidian compositional groups based on analyses of a large number of archaeological and geological obsidian samples in western Asia and beyond, providing a framework from which to interpret trade networks on a massive scale.

In the last thirty years, many scholars have worked to refine source composition data in the Mediterranean, Anatolia and the Caucasus ([Acquafredda et al. 1999](#); [Balkan-Atli et al. 1999](#); [Binder et al. 2011](#); [Blackman et al. 1998](#); [Cauvin and Balkan-Atli 1996](#); [Cauvin et al. 1998](#); [Chataigner 1994](#); [Chataigner and Gratuze 2014a](#); [Chataigner et al. 2014](#); [Frahm 2012](#); [Francaviglia 1984](#); [1988](#); [1990](#); [1994](#); [Gratuze 1998](#); [1999](#); [Keller et al. 1996](#); [Le Bourdonnec 2006](#); [Lugliè et al. 2006](#); [Montigny et al. 1991](#); [Poidevin 1998](#); [Poupeau et al. 1998](#); [Tykot 1997](#)). As a result of this ongoing work, matches between obsidian artifacts and specific source outcrops are increasingly possible, allowing for a developing picture of diachronic patterns in exchange.

Ironically, the gaps in datasets highlight the simultaneous need for finer-tuned sampling and analysis of sources and artifacts and larger spatial and chronological representation of site data. One of the most intractable obstacles to the reconstruction of prehistoric networks in western Asia has been the long-standing challenge of distinguishing the peralkaline sources of Nemrut Dağ and Bingöl A. Recent breakthroughs in their distinction and subsequent reanalysis and reattribution after forty years of uncertain provenance are testament to the gargantuan impediment this issue has been to advancing understanding of exchange routes and interregional relations. The new results presented here and in Robin et al. ([this volume](#)) are representative of the scale to which most peralkaline obsidian circulating over the greater part of western Asia can now be attributed to the source of Nemrut Dağ and particularly to its Sıcaksu outcrop. This unprecedented discovery forces us to rethink models of exchange to account for what was a major supply center that likely had an impact on the nature and development of social, political and economic networks in prehistory. This is not to say that

the Nemrut region was necessarily at the center of economic activity, but that discussions of interregional relations and network models must now account for its persistent economic power over millennia.

3. Obsidian Analyses

3.1 Method of analyses

Most of the analyses (149 of 168) of obsidian artifacts discussed here were conducted at the Center Ernest-Babelon, IRAMAT (UMR 5060 CNRS / Univ. Orléans) using LA-HR-ICP-MS (Element XR from Thermofisher Instrument) with the protocol described by Chataigner and Gratuze (2014a and b). These were analyzed alongside geological obsidian from the Göllü Dağ (Cappadocia), Pasinler (North Turkey), Bingöl A and Nemrut Dağ (East Turkey) sources. Two different laser sources were used: an Nd YAG pulsed laser, whose frequency is quadrupled, allowing it to operate in the ultraviolet region at 266 nm (VG elemental UV microprobe), and an ArF excimer laser operating at 193 nm (Resolution M50E from Resonetics).

For three of the sites, some analyses were carried out in other laboratories. Three of nine artifacts from Dosariyah were analyzed by neutron activation analysis (INAA) by E. Pernicka (CEZA, Mannheim; see Pernicka 1992), five by LA-ICP-MS in Orléans, and one (DOS2010-257) using both methods. All of the artifacts from Tell Zeidan (35) were analyzed by LA-ICP-MS, including twelve by H. Neff and J. Jaynes (Jaynes 2009), California State University (Long Beach,) and twenty-three in Orléans. The three artifacts from As-Sabiyah were analyzed by Gilles Chazot (Université de Bretagne Occidentale, Brest, Kallweit and Davies 2010) using ICP-MS.

4. The setting, the sites and results of analyses

4.1 Geochemical results and attribution to sources

As different methods and analytical protocols were used, all elemental data are not available for all of the artifacts (Table 1, 2), especially for those analyzed by INAA (e.g. Y, Nb, Sr and Ba were not determined). Some systematic deviation between different laboratories due to the calibration protocol used are possible, however in most cases it has been possible to compare analytical datasets obtained by these laboratories. Only one artifact from Dosariyah was difficult to assign with certainty to the Armenian obsidian sources of Gegham or Sjunik.

As demonstrated in Fig. 2, a majority of artifacts exhibit high concentration of iron and zirconium (104 among 168). A large number (91) have an iron content ranging from 19000 to 25000 ppm while that of the 13 other artifacts ranges from 29000 to 35500 ppm.

Fig. 2

Using the dataset of the GeObs project (Robin et al, this volume), the main group, which is peralkaline, can be assigned to the obsidian flows of the Nemrut Dağ volcano (Sıcaksu) while the smaller groups of peralkaline obsidian can be assigned to obsidian outcrops located in the Bingöl A area (Fig. 3).

Fig. 3

The 64 remaining artifacts form 9 main chemical groups (Fig. 4) related to the obsidian sources or outcrops of Bingöl B (31), Meydan Dağ (16), Pasinler (4), Arteni (2; one from Arteni 3 and one from Arteni 2), Sarıkamiş (5; 3 related to Sarıkamiş North, 2 to Sarıkamiş South), Gegham (1), Gegham or Sjunik (1 analyzed by INAA), Erzincan (1). Finally the 3 remaining artifacts exhibit high rubidium concentrations and correspond to the source referred to as '3D' by Renfrew et al. (1966).

The source '3D' is characterized by high contents of lithium, boron, rubidium and cesium and artifacts matching this group have consistently been of poor quality and are often found with artifacts from the Lake Van and Taurus areas (Bingöl, Nemrut Dağ, Meydan Dağ). Its exact location remains unknown, however, recent geological work by the GeObs program points to a probable location around Bingöl area as was proposed by C. Chataigner (see [Cauvin et al 1998: 317](#)).

Provenance		Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	K ₂ O	CaO	TiO ₂	MnO	Fe ₂ O ₃	Li	B	Sc	Ti	Mn	Zn	Rb	Sr	Y	Zr	Nb
Nemrut Dağ	Av. (91)	4.75	0.01	12.7	74.3	4.12	0.28	0.16	0.060	3.10	73.0	99.0	13.4	965	464	186	204	1.25	102	1069	61.5
	Std.	0.35	0.02	0.9	1.3	0.28	0.08	0.01	0.003	0.17	4.8	9.6	6.2	78	21	18	10	3.67	13	118	5.3
Bingöl B	Av. (31)	4.44	0.16	16.2	71.7	4.67	0.73	0.19	0.038	1.80	65.3	60.0	12.5	1128	298	47.2	213	35.0	22.7	270	16.6
	Std.	0.16	0.01	1.0	0.7	0.23	0.06	0.02	0.001	0.10	7.3	5.2	4.4	112	9	6.6	12	3.3	4.1	36	1.6
Bingöl A	Av. (13)	5.57	0.02	11.8	72.9	4.22	0.28	0.24	0.080	4.64	89.2	133.1	7.53	1438	616	193	211	1.42	110	1128	51.5
	Std.	0.75	0.01	0.6	0.8	0.23	0.04	0.02	0.010	0.27	7.8	13.9	3.61	97	80	18	10	2.02	10	119	4.1
Meydan Dağ	Av. (16)	4.78	0.05	13.9	74.7	4.11	0.45	0.077	0.067	1.40	93.2	40.1	13.4	461	520	84.5	195	14.5	40.9	229	31.6
	Std.	0.19	0.01	0.8	0.9	0.21	0.04	0.007	0.002	0.10	8.3	5.9	3.6	44	12	9.7	8	3.4	5.9	24	2.1
Pasinler	Av. (4)	4.07	0.05	13.8	75.9	4.45	0.42	0.093	0.048	1.13	44.7	29.6	8.66	557	368	42.1	175	2.97	24.9	146	24.9
	Std.	0.11	0.02	1.1	1.0	0.14	0.02	0.014	0.003	0.03	8.8	1.4	4.91	86	23	5.3	5	1.24	1.7	27	0.3
Sarıkarnış North	Av. (3)	4.55	0.04	13.8	75.2	4.34	0.32	0.081	0.079	0.70	58.1	31.3	9.68	485	611	64.5	153	6.27	38.6	112	31.1
	Std.	0.11	0.00	0.8	1.3	0.20	0.09	0.002	0.007	0.07	13.5	2.5	7.26	14	56	9.7	9	0.42	3.1	10	1.5
Sarıkarnış South	Av. (2)	4.03	0.06	13.1	76.9	4.31	0.51	0.086	0.043	0.83	39.6	25.7	14.0	515	333	33.1	127	17.6	16.2	74.6	12.7
	Std.	0.11	0.00	0.4	0.6	0.18	0.05	0.013	0.001	0.03	2.0	4.0	2.0	77	6	1.3	2	3.3	2.1	18.1	0.04
3D	Av. (3)	4.07	0.04	14.9	73.7	4.37	0.63	0.076	0.047	1.78	301	327	7.70	458	365	106	448	10.9	25.1	192	31.0
	Std.	0.15	0.00	0.5	0.7	0.09	0.03	0.005	0.003	0.09	7	10	3.58	28	20	5	9	0.8	2.1	12	1.5
Arteni 2	Zeidan (Ubaid)	5.10	0.05	12.5	76.9	4.17	0.44	0.065	0.077	0.49				389	595	38.3	129	14.9	23.1	51.9	28.4
Arteni 3	Majnuna (LC3)	4.25	0.06	12.7	77.2	4.33	0.54	0.081	0.066	0.63	45.1	40.1	14.3	484	507	38.0	116	21.1	13.6	50.3	25.5
Gegham	Dosariyah	3.96	0.04	15.8	75.0	4.00	0.58	0.061	0.076	0.47	55.9	43.0	11.7	368	586	26.9	187	7.75	18.1	53.4	46.6
Gegham or Sjunik	Dosariyah	4.68				5.18				0.63							231			90.0	
Erzincan	as-Sabiyah	4.80		11.2	75.2	4.57		0.10		2.74				599			120	53.6	528	33.4	
Provenance		Cs	Ba	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
Nemrut Dağ	Av. (91)	7.17	0.89	84.1	184	19.1	75.5	16.5	0.40	16.6	2.97	18.1	3.86	11.0	1.62	11.6	1.70	23.3	3.49	24.2	8.86
	Std.	0.57	0.83	9.6	14	2.1	9.3	1.8	0.11	3.2	0.31	2.2	0.55	1.0	0.20	1.5	0.31	2.6	0.29	3.0	0.65
Bingöl B	Av. (31)	10.1	306	34.3	66.3	5.91	20.5	3.65	0.42	3.76	0.59	3.53	0.76	2.27	0.37	2.76	0.42	6.57	1.39	25.2	9.86
	Std.	0.5	24	3.6	5.0	0.46	2.2	0.32	0.04	0.46	0.07	0.31	0.07	0.19	0.04	0.24	0.06	0.67	0.13	2.6	0.72
Bingöl A	Av. (13)	11.8	2.4	112.9	229	23.04	98.5	20.6	0.75	19.3	3.39	21.2	4.38	12.9	1.87	13.4	1.91	25.8	3.53	31.4	10.5
	Std.	1.0	2.3	26.7	45	3.46	20.5	2.1	0.15	1.9	0.34	1.7	0.36	1.1	0.16	1.3	0.21	3.5	0.37	3.1	1.0
Meydan Dağ	Av. (16)	9.02	49.9	27.4	63.9	6.55	24.8	5.86	0.31	5.24	1.05	6.63	1.40	4.08	0.64	4.54	0.68	6.70	2.00	21.4	9.38
	Std.	0.32	11.3	2.4	3.7	0.46	2.1	0.51	0.07	0.71	0.10	0.61	0.14	0.41	0.07	0.41	0.07	0.67	0.14	2.3	0.64
Pasinler	Av. (4)	5.88	18.3	43.5	77.7	6.89	22.9	4.34	0.06	3.59	0.72	4.60	1.03	2.78	0.47	3.16	0.56	5.10	1.94	32.1	10.4
	Std.	0.35	9.0	6.8	9.6	0.85	1.5	0.50	0.04	1.06	0.14	0.71	0.27	0.07	0.07	0.31	0.15	0.35	0.35	0.4	0.2
Sarıkarnış North	Av. (3)	5.30	98.2	22.3	48.6	4.95	18.9	4.73	0.19	4.57	0.99	6.39	1.37	4.12	0.62	4.62	0.66	4.68	1.94	19.3	8.04
	Std.	0.36	11.9	2.0	1.8	0.49	1.9	0.61	0.0003	0.76	0.14	1.05	0.22	0.77	0.12	0.93	0.10	0.58	0.18	2.3	0.21
Sarıkarnış South	Av. (2)	4.46	400	22.2	43.2	3.66	12.3	2.31	0.29	2.36	0.42	2.59	0.53	1.60	0.26	1.85	0.30	2.52	0.86	14.0	6.45
	Std.	0.49	48	4.6	4.2	0.60	2.5	0.53	0.04	0.23	0.03	0.18	0.07	0.23	0.03	0.23	0.03	0.43	0.02	2.5	0.39
3D	Av. (3)	38.7	26.2	49.3	91.4	8.42	28.2	5.69	0.18	4.34	0.78	4.32	0.83	2.47	0.37	2.62	0.37	5.00	3.21	45.3	19.8
	Std.	1.4	1.0	6.1	7.2	0.70	2.4	0.50	0.01	0.10	0.08	0.42	0.07	0.25	0.02	0.15	0.05	0.50	0.22	5.5	0.7
Arteni 2	Zeidan (Ubaid)	3.41	98	13.8	26.9	2.94	10.2	2.33	0.33	3.9	0.80	3.79	0.84	1.20	0.26	1.47		2.3	1.75	10.6	7.63
Arteni 3	Majnuna (LC3)	3.19	270	15.5	35.7	2.85	8.61	1.92	0.24	1.68	0.39	2.22	0.43	1.27	0.20	1.50	0.26	1.95	1.53	11.0	6.71
Gegham	Dosariyah	7.02	9.38	14.2	27.7	2.68	9.71	2.47	0.15	2.33	0.44	2.85	0.63	1.87	0.27	1.96	0.29	2.50	3.87	24.3	13.5
Gegham or Sjunik	Dosariyah	8.70	< 310	19.1	34.3		20.0	3.78	0.55		0.71					4.00	0.32	3.18	4.90	30.7	16.4
Erzincan	as-Sabiyah		0.84	41.1	92.6	10.0	38.7	8.38	0.21	9.20	1.40	9.46	1.97	5.78	0.88	6.00	0.90	11.5	2.11	12.0	4.38

Table 1

257 Fig. 4

258

Obs # per	Source													
Site	Nemrut Dağ	Meydan Dağ	Bingöl A	Bingöl B	3 D	Sarıkamış S	Sarıkamış N	Pasinler	Arteni 3	Arteni 2	Gegham	Gegham / Sjunik	Erzincan	TOTAL
Zeidan (Halaf-LC2)	15	1	7	7	1	0	0	3	0	1	0	0	0	35
Khirbet Derek (Halaf)	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Um Dabagyah (Halaf?)	2	0	1	1	0	0	0	0	0	0	0	0	0	4
Arpachiyah (Halaf)	2	0	0	0	1	0	0	0	0	0	0	0	0	3
Kheit Qassim (Ubaid)	4	1	0	0	0	0	0	0	0	0	0	0	0	5
Dosariyah (Ubaid 2/3)	5	0	1	0	0	0	0	1	0	0	1	1	0	9
as-Sabiyah (Ubaid 2/3)	2	0	0	0	0	0	0	0	0	0	0	0	1	3
Wadi Debay'an (Ubaid 2/3)	0	0	4	0	0	0	0	0	0	0	0	0	0	4
Surezha (LC1-3)	16	6	0	0	1	1	1	0	0	0	0	0	0	25
Khirbat al- Fakhar (LC1-2)	28	1	0	2	0	0	2	0	0	0	0	0	0	33
Brak (LC2)	7	4	0	6	0	1	0	0	0	0	0	0	0	18
Majnuna (LC3)	10	3	0	14	0	0	0	0	1	0	0	0	0	28
TOTAL	91	16	13	31	3	2	3	4	1	1	1	1	1	168

259 Table 2

260 4.2 Halaf - LC3 Northern Mesopotamian sites

261 Tell Zeidan (Halaf – LC2)

262 Tell Zeidan is a 12.5 hectares located at the confluence of the Euphrates and Balikh rivers in
263 north central Syria. It consists of a large southern mound 15 m in height, a lower town, and
264 two smaller mounds: the northeast and northwest mounds. It was excavated between 2008
265 and 2010 by the Oriental Institute (University of Chicago) and the Syrian General Directorate
266 of Antiquities and Museums (DGAM). A continuous occupation sequence covers the Halaf to
267 LC2 periods. A number of Ubaid domestic contexts as well as the outer wall of a large public
268 building were excavated. Specialized production is demonstrated by prestige goods made
269 from exotic materials, as well as a clay boat model and ceramic wasters and a large number
270 of spatially concentrated pyrotechnic features – apparently Ubaid pottery kilns. 99% of
271 ceramics were northern Ubaid, combining typically southern Mesopotamian geometric
272 decoration with local animal and human figural motifs. Area D produced domestic
273 architecture spanning the late Ubaid to LC1 transition, while Area E revealed LC1 and LC2
274 domestic occupation and burials (approximately 40). Area F produced an LC2 pottery kiln

275 providing evidence of on-site ceramic production during this period. Following the LC2
 276 period, the site was abandoned until the 3rd millennium BC (Stein 2010-2011).

277 *Obsidian from Tell Zeidan*

278 Obsidian is found in all areas and most contexts at Tell Zeidan (Table 3) with the greatest
 279 concentration being in the northeast mound area. Preliminary analysis indicates that obsidian
 280 accounts for between 4 and 7% of the chipped stone assemblage depending on the area. Most
 281 obsidian artifacts are of green peralkaline obsidian, but transparent greys, browns and reds
 282 are also present. Analysis of their geologic origin demonstrates that they match an unusually
 283 high number of sources. As discussed below there is some evidence to suggest that some
 284 obsidian (almost exclusively the green peralkaline type) was worked at Zeidan.

	Cores	Splintered pieces	Blades	Chipped, unworked and frags	Samples extracted (not yet classified)	Totals	Weight in g
South Mound (78% green)							
Operation 1			18	7	5		
Operation 8	2		24	9	3		
Operation 9	0	1	6	5	4		
Subtotal S mound	2	1	48	21	12	84	145.9
Northeast Mound (63% green)							
Operation 7	0		6	2	1		
Operation 11	1	1	89	20	2		
Operation 14	0		30	7			
Operation 3	0	1	16	13	2		
Operation 4	0		12	3	1		
Subtotal NE mound	1	2	153	45	6	207	334.7
Northwest mound (80% green)							
Operation 2	0		15	11	4	30	77
TOTALS	3	3	216	77	22	321	557.6

Table 3

The assemblage is comprised predominantly of blades (>70%); although rare, there are also cores, core fragments and crested blades suggesting that at least some of the obsidian was reduced at Zeidan. Three splintered pieces were also recorded (Fig. 5: 11-12). Flakes, chips and other debris account for 24% of the assemblage. One large blade core measuring 12.4 cm in length and weighing 81.9 g featuring a crested back and an obliquely set striking platform (not included in preliminary totals; Fig. 6) came from a Late Chalcolithic context in Operation 3 on the northeast mound.

Fig. 5

The other complete core is from an Ubaid context in Operation 1 on the south mound and is much smaller (Fig. 5: 1). It measures 5.6 cm in length and weighs 14.8g featuring a horizontal platform and flat back with blades removed around three quarters of the perimeter. As well as the core, blades exhibit technological attributes associated with pressure flaking (Pelegrin 2012); most are narrow (41% were 10 mm or less and a further 38% between 10 and 15 mm wide), and only 20% are wider (Fig. 5: 7-9; Fig. 7). Modification is rare and almost entirely takes the form of retouch on the edge of the blade; there are also a small number of non-tool items from Operation 11 (not listed in Table 3) including a substantial basal fragment of a bowl of transparent grey obsidian (Stein 2010: 115, Fig. 19), a v-perforated button and another flat piece with a heavily ground ventral face.

Fig. 6 HERE

Fig. 7 HERE

The techno-typological aspect of the Zeidan assemblage is different from the broadly contemporary Ubaid assemblage of Kenan Tepe in the Tigris valley near Bismil, where obsidian accounted for almost 25% of the chipped stone. At Kenan Tepe flakes were more usual than blades but this may reflect the type of obsidian being used (some of which is of poor quality and often in the form of small nodules). Even so, two obsidian bowls and a bead were also present in the Kenan assemblage suggesting that it, like Zeidan, may have had other more prestigious connections. (Healey 2006, 2009; Healey forthcoming).

Tell Zeidan geochemical results

Thirty-five obsidian artifacts from Tell Zeidan form seven groups ([Table 4](#)).

The data comprise the largest number of sources represented for any Ubaid Near Eastern site to date, which suggests that Ubaid Tell Zeidan was linked to a complex, multi-stranded obsidian exchange network that included the eastern source zones of Anatolia and the western Caucasus region.

The most represented source in Ubaid period contexts at Tell Zeidan is Nemrut Dağ (Sıcaksu outcrop), followed by Bingöl B (Aletepe and Catak outcrops; calcalkaline Bingöl) and Bingöl A (peralkaline Bingöl).

Very few obsidian artifacts were analyzed from later contexts at the site and therefore may not be representative. Nonetheless, the source matches suggest that besides the single object analyzed from the Ubaid/LC1 transition that matched Bingöl A, Nemrut Dağ continued to be a major supply zone until the LC2 period. The only other source represented in Late Chalcolithic contexts thus far is Bingöl B.

The results of the geochemical analyses suggest that Nemrut Dağ was a major supplier of obsidian to sites across the Near East and that the Ubaid period marked an increase in the extent of the obsidian exchange network, introducing a larger variety of obsidian to certain sites such as Tell Zeidan and Kenan Tepe (five sources represented; Frahm in [Healey forthcoming](#)). Given the diversity of obsidian found at Ubaid Tell Zeidan and Kenan Tepe, this period appears to have witnessed not only exploration of territory but also of obsidian resource acquisition, two things that are likely inextricably connected.

Though sample quantities are small, the Tell Zeidan Late Chalcolithic obsidian source matches reflect contemporaneous patterns in obsidian acquisition strategies at Tell Brak and Tell Hamoukar, where Nemrut Dağ, followed by Bingöl B, were the major suppliers in Late Chalcolithic 1/2 contexts.

Breakdown of number of artifacts analyzed per source/period – Tell Zeidan								
# OBS PER PERIODS	SOURCE							
	Nemrut Dağ	Meydan Dağ	Bingöl A	Bingöl B	3D	Pasinler	Arteni 2	TOTAL
Halaf-Ubaid Transition	1							1
Ubaid	9	1	5	6	1	2	1	25
Ubaid/LC1			2					1
LC1	2			1				3
LC2	3							3
Unknown						1		1
TOTAL	15	1	7	7	1	3	1	35

[Table 4](#)

Surezha (LC1-3)

Surezha is a 31 hectare mounded site located 20 km south of Erbil in Iraqi Kurdistan. The Chalcolithic occupation of the site is concentrated on the 2.8 ha high mound. Investigation of this site by the Oriental Institute began in 2013 and continues today. Systematic survey has revealed occupation from the Ubaid to Uruk periods. Ubaid levels had not yet been reached at

the time of the analyses, therefore all artifacts pertaining to this site date to the LC1-LC3 periods.

Excavations revealed intact LC1 (4800-4200 BC) domestic architecture and exterior surfaces. Radiocarbon dates, corroborated by ceramic studies, date the beginning of the LC1 in this part of Upper Mesopotamia 300 years earlier than in the neighboring Khabur region (Stein and Alizadeh 2013-2014: 149).

At Surezha, obsidian fragments analyzed were recovered from LC1 levels that include one LC1 pit context, interior surfaces in domestic contexts, and collapse levels, as well as from LC2 mudbrick collapse and detritus levels, LC2/3 transition trash deposits and a variety of LC3 contexts including ashy pits, floors, trash pits and mudbrick detritus levels.

Obsidian from Surezha

Obsidian is present at Surezha in the form of prismatic blades and knapping debris, but it comprises a relatively small component of the chipped stone assemblage. Preliminary analyses of the chipped stone have so far focused on the chert blade tools (99) with fully preserved widths among which many have remains of bitumen and silica.

Surezha geochemical results

Twenty-five obsidian artifacts from Surezha form five groups (Table 5).

Lake Van sources dominate the analyzed Late Chalcolithic obsidian assemblage at Surezha, with Nemrut Dağ (Sıcaksu) matching the greatest number of artifacts across levels. The largest number of sources represented is found in the LC1 period, where the elusive ‘3D’ appears, as well as a small sample from Sarıkamiş South and North in northeast Turkey. Sarıkamiş North is also represented at the contemporary site of Khirbat al-Fakhar, while Sarıkamiş South is represented in LC2 levels at Tell Brak (TW).

Breakdown of number of obsidian artifacts analyzed per source/period – Surezha						
# OBS PER	SOURCE					
	Nemrut Dağ	Meydan Dağ	3D	Sarıkamiş South	Sarıkamiş North	TOTAL
PERIODS						
LC1	3	3	1	1	1	9
LC2	3	3				6
LC2/3	2					2
LC3	7					7
Unknown	1					1
TOTAL	16	6	1	1	1	25

Table 5

Tell Hamoukar's Khirbat al-Fakhar (LC1-2)

Khirbat al-Fakhar is located midway between the Tigris River and Khabur basin in northeast Syria and lies due south of the Tell Hamoukar mound. It was mainly occupied in the late 5th millennium BC or LC1-2 periods (ca. 4300-3850 BC), before being abandoned. Systematic survey across the site demonstrated dense artifact scatter of LC1-2 date over an area of 300 hectares (Ur 2002: 64; 2010). The site is characterized by a low mounded center surrounded by an extensively plowed area densely strewn with artifacts.

The low mounded area was excavated in three trenches, which revealed three consecutively occupied architectural levels (I-III) that support the presence of sedentary manufacturing households. Soundings (1-10) carried out beyond this area presented poorly preserved remains of LC1-2 architecture and pits. T. J. Wilkinson proposed that these remains were left by seasonal mobile groups (Khalidi and Gratuze 2013; Wilkinson 2002: 99). Site size is significantly bigger than any other site of the period and for millennia thereafter. The morphology of the site is unique and may reflect an atypical version of proto-urbanism whereby population aggregation occurred in the form of a center with dispersed sedentary households hosting large numbers of seasonal mobile groups along its periphery, rather than the more commonly accepted form of a city as a densely populated and physically constrained area.

This site grew in an anomalous way contemporary with regional urbanism: site sizes expanded, site hierarchies became apparent, and populations aggregated into centers, all during a period when relations with southern Mesopotamia had waned. The study of the materials recovered allows us to better reconstruct the functioning of such a site within a larger regional system and to assess what would have attracted populations, enabling such unprecedented site size, albeit at low density.

Across the LC1-2 levels and areas excavated, there is evidence of on-site mass production of ceramics. Increased standardization of forms, use of chaff temper, and decline in decoration characterize this local ceramic production and gradually distinguish it from preceding periods (Al Quntar and Abu Jayyab 2014: 99). Obsidian blade production occurred in quantities that reflect intensive on-site activity. The large quantities of obsidian excavated (> 5000 artifacts) from LC1-2 levels are seldom seen at sites in the region or at distances of 200-300 km from source areas (Khalidi and Gratuze 2013). While Khirbat al-Fakhar's size and its obsidian quantities are an anomaly for the period and the region, the site likely developed in a unique way in response to growing populations and their needs, and to intensified interaction and exchange.

Obsidian from Khirbat al-Fakhar

The obsidian discussed here originates from excavations in the mounded area and from a sounding (10) in the non-mounded portions of the site. Obsidian makes up 97% of the raw material used for tool-making at Khirbat al-Fakhar. Every stage of obsidian manufacture is found, from neo-cortical blade core preparation flakes to final products (mainly blades), strongly suggesting on-site production. However, 70% of the obsidian studied from these excavations is made up of blades and another 6% of other tool forms. The remaining 24% is made up of cores and core trimming debris. This implies that more than 3/4 (76%) of the obsidian remains were final products for consumption and/or trade. All blade cores studied were single platform. Blades suggest the use of a pressure debitage technique although percussion techniques are evident in core preparation and core trimming debris.

Khirbat al-Fakhar geochemical results

Thirty-three obsidian artifacts form four groups (Table 6).

Twenty-eight obsidian artifacts analyzed match Nemrut's Sıcaksu outcrop. Save for two samples from Sarıkamış North, the great majority of sources represented are located in the Lake Van region of eastern Anatolia. Interestingly, Bingöl A is not represented in the analyzed assemblage of peralkaline archaeological obsidian from this site, despite such obsidian predominating (99%) in the total assemblage (Khalidi and Gratuze 2013: 19).

Results point to direct relations between Khirbat al-Fakhar and Nemrut Dağ that were linked, at least in part, to obsidian acquisition. The presence of a few finished elements originating from the Lake Van region in which Nemrut is situated are expected. The representation of a small sample from Sarıkamiş North is enigmatic but may have had more to do with existing networks between northeast Anatolia and Nemrut than with direct links between Khirbat al-Fakhar and the Sarıkamiş area.

Breakdown of number of artifacts per source/period – Khirbat al-Fakhar					
# OBS PER	SOURCE				
	Nemrut Dağ	Meydan Dağ	Bingöl B	Sarıkamiş North	TOTAL
PERIODS					
LC1-LC2	28	1	2	2	33
Phase I or later	8		2		10
Phase II	7	1			8
Phase III	13			2	15
mound	6			1	7
extension	7			1	8
TOTAL	28	1	2	2	33

Table 6

Tell Brak (LC2-LC3)

Tell Brak is situated in the southern part of the dry farming zone in the upper Khabur Plain, northeastern Syria. The tell is one of the largest sites in northern Mesopotamia with a height of 40 m and a surface area of 130 hectares. This large gateway site, strategically placed on major exchange routes that linked southern Mesopotamia, the upper Tigris and western Syria, had grown to 55 hectares (Ur et al. 2007) in the LC2 period (4200-3800 BC) concentrated on the central mound. The site reached its maximum extent of 130 hectares (Ur et al. 2007) in the LC3 period (3900-3600 BC) when its outer town was settled. This outer town comprised a corona of small sub-mounds and a ring of low-density occupation between the corona and central mound. Tell Majnuna, 450 m north of the central mound, is the largest of the sub-mounds, at 2-3 hectares and 7 m high.

The late 5th to 4th millennia occupation (LC2-LC3) at Brak was excavated in several areas on the central mound and outer town. Area TW features a sequence that spans the entire 4th millennium BC. During the LC2 period, the area was an industrial zone adjacent to a monumental building with a large basalt threshold and thick mudbrick walls; its function remains unknown but is hypothesized as secular administrative. Most of the TW obsidian analyzed was excavated from the adjacent industrial zone, which provided evidence of centralized ceramic, stone tool and textile manufacture, as well as the production of elite items such as beads, inlay and unique objects such as an obsidian chalice (Khalidi 2014). The obsidian (18) analyzed from TW pertains to LC2 level 21, which may have had a temporal overlap with occupation of Khirbat al-Fakhar.

During the LC3 period, Area TW's function shifted to feasting, and industry may have moved to the Outer Town. Tell Majnuna and adjacent outer town sub-mounds, such as T2, were most intensively occupied during this period

Tell T2 had mixed domestic occupation and intensive industry, mainly manufacture of pottery and possible textile dyeing or leather tanning (McMahon & Stone 2013). However, Majnuna is anomalous to any other excavated mounds in that it served solely as a rubbish

dump for discard of garbage from the dense occupation on the central mound, accumulating via a series of managed and large-scale episodes. Excavation at Majnuna also revealed a series of mass graves dating between 3900 and 3700 BC. These mass graves are secondary single-episode deposits that have been interpreted as the outcome of warfare based on analysis of stratigraphy, forensics, age-curves and pathologies (McMahon et al. 2011). The graves were covered by layers of rubbish consisting of ash, soil, broken pottery, tools, container sealings, and animal remains.

Obsidian from TW, Tell Majnuna and T2

Eighteen obsidian samples excavated from LC2 level 21 in area TW were analyzed. Eight of these were re-analyzed (Khalidi et al. 2009) in order to conclusively distinguish their peralkaline origins. This level contained relatively ephemeral and unplanned structures, ovens and other industrial features built alongside a major N-S street leading into the city. Obsidian dominates the lithic assemblage in this level and is used to make pressure blades and prestige objects such as beads and pendants. While knapping of blades and objects occurred on-site, several blades were traded to the site as finished products. The scale and intensity of the industries intensified in the following Level 20, where the same lithic tradition continued but with a gradual increase in larger and thicker chert blade products. Obsidian analyzed came from outdoor (street, pits, courtyards) as well as indoor (floors, fill, bins, ovens) contexts.

Twenty-eight obsidian samples excavated from LC3 levels in the outer town mounds of Majnuna and T2 were analyzed. A study of the total lithic material from Majnuna is ongoing, however, preliminary observation has shown a large predominance of chert in the assemblages (both knapping debris and finished tools) and production of wider and thicker chert blades than in previous periods. Among the obsidian recovered were few pendants and blade fragments as well as some debris. The contexts at Majnuna are within single episode LC3 rubbish dumps, while at T2, the context pertains to LC3 mixed industry.

TW, Tell Majnuna and T2 geochemical results

Forty-six obsidian artifacts form 5 groups (Tables 7, 8).

Similar to the situation at Khirbat al-Fakhar, Bingöl A is also absent among the peralkaline obsidian artifacts analyzed from Brak, while Bingöl B is present. Peralkaline obsidian makes up the vast majority (84% in Level 21 and 93% in Level 20) of the total obsidian assemblage at Brak, and was the most commonly knapped on-site (Khalidi 2014: 72). However, a greater number of non-peralkaline obsidian artifacts were selected for analysis to determine the range of less prominent sources represented. This partially explains why Bingöl B makes up the majority of obsidian analyzed from the TW and Majnuna / T2 assemblages (Table 7). Bingöl B obsidian was also knapped to make tools, beads and pendants at Brak and was an important secondary source to Nemrut Dağ (Sıcaksu) across the periods represented, unlike at Khirbat al-Fakhar.

Aside from the predominance of eastern Anatolian obsidian, we find obsidian from Sarıkamış South (northeast Turkey) in LC2 contexts at Brak, and a sample of obsidian from the Armenian source of Arteni 3 in LC3 mass grave deposits at Majnuna.

Breakdown of number of artifacts per source/site area						
# OBS PER	SOURCE					
	Nemrut	Meydan	Bingöl B	Sarıkamış	Arteni 3	TOTAL

SITES	<i>Dağ</i>	<i>Dağ</i>		<i>South</i>		
<i>EME mid LC3</i>	1					1
<i>MTW early LC3</i>	1					1
<i>MTW2 early LC3</i>			1			1
<i>MTW4 Early LC3</i>	2		8			10
<i>EM early LC3</i>	2	2	5		1	10
<i>T2E-A early LC3</i>	1					1
<i>T2E-B early LC3</i>	1					1
<i>T2E-C early LC3</i>	1	1				2
<i>GPS2</i>	1					1
<i>TW-N mid LC2</i>	3	3	3	1		10
<i>TW-SW mid LC2</i>	4	1	3			8
TOTAL	17	7	20	1	1	46

Table 7

Breakdown of number of artifacts per period at Tell Brak, Tell Majnuna, T2						
# OBS PER PERIOD	SOURCE					TOTAL
	<i>Nemrut Dağ</i>	<i>Meydan Dağ</i>	<i>Bingöl B</i>	<i>Sarıkamış South</i>	<i>Arteni 3</i>	
<i>Mid LC3</i>	1					1
<i>Early LC3</i>	8	3	14		1	26
<i>Mid LC2</i>	7	4	6	1		18
<i>Unknown</i>	1					1
TOTAL	17	7	20	1	1	46

Table 8

4.3 Comparison to Halaf and Ubaid Sites in northern Iraq

Thirteen obsidian finds collected by M.-L. Inizan in the late 70s and early 80s in the context of a French program directed by the late Jean-Daniel Forest in northern Iraq, were analyzed by LA-ICP-MS. Save for five samples (2 blades, 1 bladelet and 2 flakes) excavated from Ubaid levels at Kheit Qassim (KQIII-Z12-Carré 3) (Forest 1980; Forest-Foucault 1980; Inizan 1986), the remaining obsidian artifacts are surface finds recovered in Halaf-rich

507 surface contexts at Khirbet Derek (1 backed circle segment), Umm Dabaghiyah (2 blades and
508 2 flakes) and Arpachiyah (2 flakes and 1 drill).

509 Results of analyses on these samples show that five sources (including ‘3D’) are represented
510 across these four Halaf/Ubaid period northern Iraqi sites.

511 *Geochemical results from Halaf/Ubaid sites*

512 Thirteen obsidian artifacts form 5 groups (Table 9).

513 The majority of obsidian samples from these four sites match the Sıcaksu outcrop of Nemrut
514 Dağ and the totality of these samples originate from eastern Anatolian sources. Interestingly
515 the source ‘3D’ is found at Arpachiyah.

Breakdown of number of artifacts per source/site – Halaf/Ubaid North Iraq						
# OBS PER SITE	SOURCE					TOTAL
	Nemrut Dağ	Meydan Dağ	Bingöl A	Bingöl B	3D	
<i>Khirbet Derek</i>				1		1
<i>Umm Dabaghiyah</i>	2		1	1		4
<i>Arpachiyah</i>	2				1	3
<i>Kheit Qassim III</i>	4	1				5
TOTAL	8	1	1	2	1	13

516 Table 9

517 *4.4 Comparison to Ubaid sites in the Arabian Gulf*

518 To date, very few obsidian samples have been recovered in the Arabian Gulf region. While
519 southern Mesopotamian Ubaid ceramics are common on coastal Middle Neolithic sites in the
520 Central Gulf region and can be found as far as Ra’s al Khaimah in the northern Emirates,
521 obsidian is rare in the area. Our analyses are the first to be carried out on these few obsidian
522 elements from Gulf sites, and results provide an emerging picture of a dynamic and far-
523 reaching Ubaid interaction sphere. While obsidian counts are generally extremely low for the
524 region, 16 obsidian samples from three sites were analyzed or compared to our database and
525 provide us with five different eastern Anatolian and Armenian origins for obsidian traded to
526 the Gulf at distances often exceeding 1500 km during the Ubaid 2/3 or Middle Neolithic
527 period.

528 *Obsidian from Dosariyah (Saudi Arabia)*

529 Dosariyah is a Middle Neolithic site located approximately 10 km south of Jubail and 800 m
530 inland of the current shore of the Arabian Gulf in the Eastern Province of the Kingdom of
531 Saudi Arabia. More than 20 radiocarbon dates place the site in the late 6th and first half of the
532 5th millennium BC (Drechsler 2011: 74). As the Ubaid pottery from the site covers the range
533 of elements characteristic of the early Ubaid 3 (Ubaid 2/3) to Ubaid 4, a larger time frame for
534 the occupation of the site can be expected. The distinctively southern Mesopotamian Ubaid
535 elements at the site are clearly imports within an indigenous central Gulf Neolithic repertoire
536 that includes bifacial stone tools including projectiles, bone tools and local ceramic coarse
537 wares. At Dosariyah local ceramic wares make up 20% of ceramics (Kainert and Drechsler

2011). The main matrix of the site consists of pearl oyster shell remains and widely lacks visible architecture. There is a complete absence of later settlement making the likelihood of an Ubaid date for surface finds very high. Nine obsidian samples from this site were analyzed using two different laboratories and methods and the results were calibrated and compared.

The first series of four obsidian samples was analyzed using Neutron Activation Analysis (NAA) by EP and the second, comprising five new samples and one previously analyzed by EP, were analyzed using LA-ICP-MS by BG, to which the first series of compositions were compared.

The first series consisted of four bladelet segments. Two of these are from surface collections and include a medial and a proximal bladelet segment. The two others are medial bladelet segments recovered from excavations. Three of these are peralkaline obsidian and correspond to Nemrut Dağ (2) and Bingöl A (1), while the fourth belongs to either the Gegham or Sjunik sources in Armenia which are at least 1,500 km as the crow flies from Dosariyah.

The second series of obsidian analyzed using LA-ICP-MS by BG included six blade segments. All but one were collected on the surface of Dosariyah. Four of these were peralkaline in composition (2 proximal including that originally analyzed by EP and 2 medial). These all correspond to the source of Nemrut Dağ in eastern Anatolia. The following two blades are medial segments. The first was excavated and corresponds to the source of Pasinler in eastern Anatolia, while the second corresponds to the source of Mount Gegham in Armenia.

Results distinguish five obsidian composition groups among the nine samples, including those of eastern Anatolia, Pasinler in northeast Anatolia, and two Armenian flows. In addition, the obsidian recovered was in the form of finished blade fragments, some of which are likely pressure blades. No obsidian production debris was found, and the pressure technique has yet to be documented in Arabia. These blades comprise one of the many northern materials and objects that shifted hands, ending up at Dosariyah where populations were active participants in an Ubaid interaction sphere. This site exhibits different levels of connectedness to Ubaid period networks and underlines the importance of understanding the way such distinct networks developed, operated and merged in this unique period of intensive social networking among indigenous communities across the region.

Obsidian from As-Sabiyah (Kuwait)

Excavations at as-Sabiyah (H3) in Kuwait, the most northerly Ubaid related coastal site in the Arabian Gulf, have provided a large gamut of local and southern Mesopotamian material culture that attests to the complexity of local societies and the intensity of maritime interaction in this region in the Ubaid 2/3 period. As well as a local ceramic coarse ware (20% of the assemblage), this site has complex stone architecture and impressed bitumen slabs that confirm the presence of early seafaring technology which facilitated the growth of interaction networks.

In addition to local bifacial tools and local production of shell and pearl jewelry, H3 provided a variety of southern Mesopotamian finds including stone and ceramic flanged discs and nail-shaped objects as well as large amounts of Ubaid 2/3 pottery. As well as artifacts with clear Mesopotamian origins, at least seven obsidian bladelet fragments and flakes from Periods 4 and 3 were excavated, of which three (artifacts 1003.04, 3006.20, 3030.F10; Fig. 6.2, Carter and Crawford 2010) were analyzed by LA-ICP-MS in 2000 and 2002 by G. Chazot. At the

time of their analysis, their peralkaline composition was not comparable to source data available for Turkey and the Caucasus and G. Chazot deduced that their origins might be in Arabia or the Horn of Africa. Previous comparisons to our datasets showed vague similarities between two of these bladelets with the Yemen source of Yafa' (Kallweit and Davies 2010: 111). However, recent breakthroughs in distinctions between the two Turkish peralkaline sources of Nemrut Dağ and Bingöl A (Frahm 2012; Khalidi and Gratuze 2013), and recent systematic sampling of the former source (Robin et al. this volume), have provided new source fingerprints that can be compared with G. Chazot's data. The comparison reveals these two bladelets are very close in composition to the source of Nemrut Dağ. The third analyzed flake (1003.04) is likely to have come from the Erzincan region.

Obsidian from Wadi Debay'an (Qatar)

A program of survey during the development of the Qatar National Historic Environment Record, led to the discovery of multi-phased chenier beach ridges, a flint scatter and a cemetery all dated to the Neolithic. The sites are located within and around Wadi Debay'an, lying east of the Ras 'Ushayriq Peninsula, northwest Qatar. The flint scatter (QNHER141) is located on a slightly elevated area (3-4m), 2.5km from the modern shoreline on the northeastern edge of Wadi Debay'an.

An initial surface collection across QNHER141 included an obsidian fragment, Ubaid pottery, and stone tools (Al-Naimi et al 2010). Surface collection and excavation over subsequent seasons at QNHER141 produced >150 pottery sherds (mostly of Ubaid 3/4 period cups, jars, dishes and bowls), bifacial tools, polished stone axes and a further three obsidian fragments. Postholes and hearths excavated at the site are indicative of temporary structures built from mangroves or burasti (Cuttler et al 2011). A total of 22 calibrated radiocarbon dates from QNHER141 place occupation firmly between the mid-6th and the mid-5th millennia BC, when the wadi was probably subject to a sea level high of between +1 and +3m. Analyses by LA-ICP-MS resulted in all four obsidian samples matching the source of Bingöl A in eastern Anatolia.

Sixteen obsidian artifacts form 6 groups (Table 10).

Breakdown of number of artifacts per source/site – Ubaid 2/3 Gulf									
# OBS PER SITE	SOURCE								TOTAL
	Nemrut Dağ	Meydan Dağ	Bingöl A	Bingöl B	Erzincan	Pasinler I	Gegham	Gegham or Sjunik	
Dosariyah	3					1	1		5
Dosariyah re-analyzed	2		1					1	4
As-Sabiyah	2				1				3
Wadi Debay'an			4						4
TOTAL	7	0	5	0	1	1	1	1	16

Table 10

5. Implications for early social networks in Ubaid and Chalcolithic Mesopotamia

The results presented here show that the majority of analyzed obsidian recovered from Halaf to Late Chalcolithic sites in northern Mesopotamia and the Arabian Gulf originates from the Lake Van area in eastern Turkey.

Figure 8

The recent distinction made between the peralkaline sources of Nemrut Dağ and Bingöl A, as well as comprehensive geological work along the Nemrut Dağ volcano (Robin et al this volume), has allowed for a reassessment of previous data which has overwhelmingly provided a Nemrut Dağ origin for the majority of artifacts and across periods. These artifacts specifically match the high-quality Sıcaksu outcrop located on the western extent of Nemrut Dağ, providing us with a precise center of extraction of the largest quantities of archaeological obsidian yet analyzed. At Khirbat al-Fakhar, Tell Brak, and Tell Zeidan, obsidian matching this outcrop was preferred for on-site production, while finished products with this same origin can be found at greater distances from the PPNB (Tell Labwe south; Khalidi et al. 2013) until at least the Ubaid period where it appears in the Arabian Gulf.

The Bingöl B source is equally consistent in northern Mesopotamian assemblages and is found in the form of production debris and finished products (including objects) on a few of the sites studied. It appears to have been extremely important as a secondary source from the Neolithic until the Bronze Age. Interestingly it has not yet been identified on Ubaid sites in the Arabian Gulf despite comprehensive analysis of obsidian recovered from the three Gulf sites treated in this paper.

The source of '3D', for many years shrouded in mystery, now matches several artifacts from five northern Mesopotamian sites ranging in date from the Halaf to the Bronze Age (Tell Beydar; [Milano and Lebeau 2014](#)). It is likely to have a Bingöl localization, even if the precise outcrop has still not been identified. '3D' obsidian encountered in the few assemblages where it has appeared is generally of poor quality and workability. It is interesting to note its presence together with high-quality obsidian. Thus far, the periods during which artifacts from '3D' are found are variable and there is no discernible pattern to its presence.

Equally significant are results which demonstrate that small quantities of finished obsidian products recovered mainly from Ubaid period sites, and whose minor presence continues thereafter, have northeast Turkish (Pasinler, Erzincan) and Armenian (Gegham, Arteni) geochemical origins. Arteni, for example, is of very good quality and has been shown to have supplied obsidian in high quantities but over a limited territory in the Caucasus ([Chataigner and Gratuze 2014a](#)). Its presence at Ubaid levels at Zeidan and in LC3 contexts at Majnuna takes us beyond this limited territory. Likewise, Pasinler obsidian had only been recovered with certainty at the site of Tell Kurdu (1 bladelet, [Bressy et al. 2005](#); [Chataigner et al. 2014](#)) prior to matches to Ubaid Zeidan and Dosariyah.

These data provide a relatively comprehensive view of the spatial extent of Ubaid networks. The sites of Zeidan, Dosariyah, as-Sabiyah and Wadi Debay'an together cover the range of sources (10 of 12) represented in this dataset (save for Sarıkamiş), further highlighting the importance and uniqueness of this period for the shaping of intergroup relations and social networks. The far-reaching networks established during this period forged the way for relations with the northeastern source zones which featured in following periods, even while relations with the Arabian Gulf waned after the Ubaid.

Figure 9

In the LC1-3 periods, we witness a chronological and spatial variability in relations with source zones that are testament to the profound intra- and inter-site changes that occurred in northern Mesopotamia. The variable sizes and content of the obsidian assemblages from the sites of Zeidan, Khirbat al Fakhar and Brak are of particular interest for the Late Chalcolithic periods as they suggest a great variability in site function.

Study of obsidian assemblages from LC2 levels at Tell Brak further testifies to its role as an important gateway site to which a number of exchange networks were connected, at a time when it was growing substantially (55 ha.) and its population size required greater administration. Small-scale obsidian production was one of many industrial activities that took place there, while it also served as a center of exchange for finished products. At Late Chalcolithic levels (1/2) at Tell Zeidan, we see a similar picture to that of Brak, with a variety of eastern Anatolian sources represented in a context where on-site production was on a small scale and existed alongside exchanged obsidian finished products.

Khirbat al-Fakhar, on the other hand, grew to an unprecedented size (300 ha.) in the LC1-2. The scale of obsidian production on this site is unmatched in this region, and its relations with obsidian sources included direct links with Nemrut Dağ, which likely provided 99% of its obsidian for on-site production and exchange. Interestingly this site was not heavily populated and has a signature that can best be explained as a permanent center that hosted large numbers of itinerant populations during parts of the year. The large quantities of obsidian from the Sıcaksu flow are suggestive of direct links with transhumant populations from the Nemrut Dağ region who descended into the plains seasonally, bringing obsidian with them.

LC3 levels from Tell Majnuna and T2 provide a picture of an increasingly populated site. The mass graves of this period point to internal conflict spurred by increased aggregation during a period of climatic change. External relations visible through the limited obsidian data we have for this period in the Brak region do not show a great departure from the patterns of previous periods, save for evidence for Armenian obsidian.

The diachronic view provided by this work provides an emerging picture of periods of heightened relations (Ubaid and LC2) between northern Mesopotamia and eastern Anatolia, with obsidian networks consistently centering on the Nemrut Dağ region.

Figure 10

Wilkinson noted that major shifts in ratios of chert to obsidian, and particularly a reduction of obsidian, occurred in northern Mesopotamia during periods of intensified interaction with southern Mesopotamia (Gibson 2014: 190). Confronting this issue requires particular focus on addressing gaps in obsidian research for southern Mesopotamian sites – a consequence of a diminution of research in Iraq in the last twenty-five years – and on building standardized datasets of ratios of chert to obsidian across entire site assemblages. This issue also reinforces the need to further research the extent, if any, of southern Mesopotamian control over its adjacent regions and their resources prior to the establishment of city-states in the 3rd

millennium BC. Our data, which do not account for entire assemblage counts but for number of sources represented per period and region, demonstrate that a larger variety of sources and source regions supplied sites during periods of most interaction between southern and northern Mesopotamia. Furthermore, detailed study of obsidian assemblages from several northern Mesopotamian sites demonstrates the preponderance of peralkaline obsidian in on-site production debris, while, with the occasional exception of Bingöl B, other types of obsidian were brought or exchanged as final blade products. The overwhelming matches of peralkaline obsidian to the Nemrut Dağ source on the select samples of obsidian analyzed permits us to tentatively assume that most peralkaline obsidian which is predominant in these assemblages comes from this same source. From this perspective, we can make out a constant in the prominence of Nemrut Dağ as a major supplier across all periods, with the integration of far reaching networks during certain periods of increased interaction that would include, but not necessarily be driven by southern Mesopotamia.

The relationships between the forging and development of external relations between groups, partially visible through the mapping of obsidian networks, and the societal changes that occurred are becoming clearer with larger obsidian datasets and more detailed geological information and chemical analyses. Such networks are key to understanding the development of urbanization and potential reasons for its collapse. A preliminary diachronic view of the level and forms of contact and interaction that existed across these periods proves that understanding even one element of interregional contact enables a more profound understanding of the socio-economic changes that occurred during transitions in social complexity.

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7. Bibliography

Acquafredda, P., T. Andriani, S. Lorenzoni and E. Zanettin. 1999. Chemical Characterization of Obsidians from Different Mediterranean Sources by Non-destructive SEM-EDS Analytical Method. *Journal of Archaeological Science* 26: 315–325.

- Adams, R. M. 1981. *Heartland of Cities*. Chicago: University of Chicago.
- Algaze, G. 2008. *Ancient Mesopotamia at the Dawn of Civilisation: The Evolution of an Urban Landscape*. Chicago: University of Chicago Press.
- Al Kuntar, S. and Abu Jayyab, K. 2014. The Political Economy of the Upper Khabur in the Late Chalcolithic 1-2: Ceramic Mass-production, Standardization and Specialization. In *Preludes to Urbanism: The Late Chalcolithic of Mesopotamia. Festschrift in Honour of Joan Oates*. A. McMahon and H. Crawford (eds). McDonald Institute Monographs. Cambridge: McDonald Institute for Archaeological Research, pp. 89-108.
- Al-Naimi, F. A., R. Cuttler, H. Arrock and H. Roberts. 2010. A possible Upper Palaeolithic and Early Holocene flint scatter at Ras 'Ushayriq, western Qatar. *Proceedings of the Seminar for Arabian Studies* 40: 209-214.
- Al Quntar, S., L. Khalidi and J. Ur. 2011. Proto-urbanism in the late 5th millennium BC: survey and excavations at Khirbat al-Fakhar (Hamoukar), northeast Syria. *Paléorient* 37.2: 151-175.
- Astruc, L., B. Gratuze, J. Pelegrin and P. Akkermans. 2007. From production to use: a parcel of obsidian bladelets at Sabi Abyad II. In *Technical Systems and Near Eastern PPN Communities: Proceedings of the 5th International Workshop, Fréjus, 2004*. L. Astruc, D. Binder and F. Briois (eds). Antibes: APDCA, pp. 327-342.
- Balkan-Atli, N., D. Binder, M. C. Cauvin, E. Biçakçi, G. Der Aprahamian and C. Kuzucuoglu. 1999. Obsidian: Sources, Workshops and Trade in Central Anatolia. In *Neolithic in Turkey: The Cradle of Civilization*. M. Özdoğan and N. Başgelen (eds). Istanbul: Arkeoloji Ve Sanat Yayınları, pp. 133-143.
- Binder, D., B. Gratuze, D. Muralis and N. Balkan-Atlı. 2011. New investigations of the Göllüdağ obsidian lava flows system: a multi-disciplinary approach. *Journal of Archaeological Science* 38(12): 3174-3184.
- Blackman, J., R. Badaljan, Z. Kikodze and Ph. Kohl. 1998. Chemical characterization of Caucasian obsidian geological sources. In *L'obsidienne au Proche et Moyen Orient: du volcan à l'outil*. M. C. Cauvin, A. Gourgaud, B. Gratuze, N. Arnaud, G. Poupeau, J.-L. Poidevin and C. Chataigner (eds.). BAR International Series 738 and Maison de l'Orient Méditerranéen, R. Makjanic (general ed.). Oxford: Archaeopress, pp. 205-231.
- Bressy, C, G. Poupeau, K.A. Yener. 2005. Cultural interactions during the Ubaid and Halaf periods: Tell Kurdu (Amuq Valley, Turkey) obsidian sourcing. *Journal of Archaeological Science* 32: 1560-1565.
- Burian, F., Friedman, E. and Mintz, E. 1999. Nahal Lavan 109 - a Pre-Pottery Neolithic site in the Western Negev, Israel. In *Festschrift für Gunter Samulla. Materialien zur von - und frühgeschichte von Hessen* 8, pp. 95-120.
- Campbell, S and Healey, E. 2009. The Challenge of Characterising Large Assemblages of Exotic Materials: a case study of the obsidian from Domuztepe, SE Turkey. *Internet Archaeology* 26. (doi:10.11141/ia.26.20).

799 Campbell, S. and Healey, E. 2013. The obsidian at Arpachiyah, Iraq; an integrated study. In
800 F. Borrell, J.-J Ibáñez and M. Molist (eds). *Stone Tools in Transition: From Hunter-*
801 *Gatherers to Farming Societies in the Near East*. The Proceedings of the Seventh PPN
802 Conference on Chipped and Ground Stone Artifacts in the Near East. Barcelona, February
803 2012, pp. 529-542.

804 Cann, J.R. and C. Renfrew. 1964. The Characterization of Obsidian and its Application to the
805 Mediterranean Region. *Proceedings of the Prehistoric Society* 30: 111-131.
806

807 Carter, R. and H. Crawford (eds). 2010. *Maritime interactions in the Arabian Neolithic*,
808 Leiden.
809

810 Carter, R. and Philip, G. 2010. Deconstructing the Ubaid in *Beyond the Ubaid:*
811 *Transformation and Integration in the Late Prehistoric Societies of the Middle East*. R.
812 Carter and G. Philip (eds). Studies in Ancient Oriental Civilization, Number 63. Chicago:
813 The Oriental Institute of the University of Chicago, pp. 1-22.

814 Carter, R. 2006. Boat remains and maritime trade in the Persian Gulf during the sixth and
815 fifth millennia BC. *Antiquity* 80: 52-63.
816

817 Cauvin, M. C. and N. Balkan-Atli. 1996. Rapport sur les recherches sur l'obsidienne en
818 Cappadoce. 1993-1995. *Anatolia Antiqua* IV: 249-271.
819

820 Cauvin, M. C., A. Gourgaud, B. Gratuze, N. Arnaud, G. Poupeau, J.-L. Poidevin and C.
821 Chataigner (editors). 1998. *L'obsidienne au Proche et Moyen Orient: Du volcan à l'outil*.
822 Oxford : Archaeopress.
823

824 Chataigner, C. 1994. Les propriétés géochimiques des obsidiennes et la distinction des
825 sources de Bingöl et du Nemrut Dag. *Paléorient* 20 (2): 9-17.
826

827 Chataigner, C., Gratuze, B. 2014a. New data on the exploitation of obsidian in the Southern
828 Caucasus (Armenia, Georgia) and eastern Turkey. Part 1: Source characterization.
829 *Archaeometry* 56: 48-69. (<http://dx.doi.org/10.1111/arcm.12006>).
830

831 Chataigner, C., Gratuze, B. 2014b. New Data on the Exploitation of Obsidian in the Southern
832 Caucasus (Armenia, Georgia) and Eastern Turkey, Part 2: Obsidian Procurement from the
833 Upper Palaeolithic to the Late Bronze Age. *Archaeometry* 56: 25-47.
834 (<http://dx.doi.org/10.1111/arcm.12007>).
835

836 Chataigner C., Işıklı M., Gratuze B., Çil V. 2014. Obsidian Sources in the Regions of
837 Erzurum and Kars (North-East Turkey): New Data. *Archaeometry* 56: 351-374.
838 (<http://dx.doi.org/10.1111/arcm.12011>).
839

840 Crassard, R. and Khalidi, L. in press. "Dispersals, Inter-Regional Connections and the
841 Development of the Arabian Neolithic". In Petraglia, M., Boivin, N. and R. Crassard (eds).
842 *Proceedings of the Fyssen Foundation Symposium "From Colonisation to Globalisation:*
843 *Species Movements in Human History"*. CUP.

844 Cuttler, R., Tetlow, E. and Al-Naimi, A. F. 2011. Assessing the value of palaeoenvironmental
845 data and geomorphological processes for understanding late Quaternary population dynamics
846 in Qatar. *Proceedings of the Seminar for Arabian Studies* 41:1-14.

- Drechsler, P. 2011. Places of contact, spheres of interaction. The Ubaid phenomenon in the central Gulf area as seen from a first season of reinvestigations at Dosariyah (Dawsāriyyah), Eastern Province, Saudi Arabia. *Proceedings of the Seminar for Arabian Studies* 41: 69-82.
- Forest, J.-D. 1980. Kheit Qassim I: un cimetière du début du troisième millénaire dans la vallée de Hamrin, Iraq. *Paléorient* 6: 213-220.
- Forest-Foucault, Ch. 1980. Rapport sur les fouilles de Kheit Qasim III-Hamrin. *Paléorient* 6: 221-224.
- Frahm, E. 2012. Distinguishing Nemrut Dağ and Bingöl A Obsidians: Geochemical and Landscape Differences and the Archaeological Implications. *Journal of Archaeological Science* 39: 1436-1444.
- Francaviglia, V. M. 1984. Characterization of Mediterranean Obsidian Sources by Classical Petrochemical Methods. *Preistoria Alpina* 20: 311-332.
- Francaviglia, V. 1988. Ancient Obsidian Sources on Pantelleria (Italy). *Journal of Archaeological Science* 15: 109-122.
- Francaviglia, V. M. 1990. Les gisements d'obsidienne hyperalkaline dans l'Ancien Monde: étude comparative. *Revue d'Archéométrie* 14: 43-64.
- Francaviglia, V. M. 1994. L'origine des outils en obsidienne de Tell Magzalia, Tell Sotto, Yarim Tepe et Kül Tepe, Iraq. *Paléorient* 20(2): 18-31.
- Gibson, M. 2014. Summary. In *Preludes to Urbanism: The Late Chalcolithic of Mesopotamia*. A. McMahon and H. Crawford (eds). McDonald Institute Monographs. Cambridge: McDonald Institute for Archaeological Research, pp. 189-192.
- Gratuze, B. 1998. Les méthodes de caractérisation de l'obsidienne. In *L'obsidienne au Proche et Moyen Orient: du volcan à l'outil*. M. C. Cauvin, A. Gourgaud, B. Gratuze, N. Arnaud, G. Poupeau, J.-L. Poidevin and C. Chataigner (eds). BAR International Series 738 and Maison de l'Orient Méditerranéen, R. Makjanic (general ed). Oxford: Archaeopress, pp. 31-48.
- Gratuze, B. 1999. Obsidian characterisation by laser ablation ICP-MS and its application to the prehistoric trade in the Mediterranean and the Near East: The sources and distribution of obsidian within the Aegean and Anatolia. *Journal of Archaeological Science* 26: 869-881.
- Healey, E. 2006. "Lithics". In B. J. Parker, L. Dodd, A. Creekmore, E. Healey and C. Painter The Upper Tigris Archaeological Research Project (UTARP): A Preliminary Report from the 2003 and 2004 Field Seasons at Kenan Tepe. *Anatolica* XXXII: 23-27.
- Healey, E. 2009. The chipped stone assemblage from Ubaid contexts. In B. J. Parker, C. P. Foster, K. Nicoll, J. R. Kennedy, P. Graham, A. Smith, D. E. Hopwood, M. Hopwood, K. Butler, E. Healey, M. B. Uzel and R. Jensen. The Upper Tigris Archaeological Research Project (Utarp): A Preliminary Report from the 2007 and 2008 Field Seasons at Kenan Tepe. *Anatolica* XXXV: 123-128.

- 896 Healey, E. Forthcoming. The Lithic artefacts from the Ubaid Period Contexts at Kenan Tepe.
897 In B. Parker. *The Excavations at Kenan Tepe* (provisional title).
- 898 Inizan, M.-L. 1986. Technologie et Préhistoire récente en Mésopotamie : l'exemple du
899 débitage par pression et de l'économie de l'obsidienne. In *Coll. intern. du C.N.R.S.*
900 *Préhistoire de la Mésopotamie*. December 1984. Paris: éditions C.N.R.S. pp. 305-315.
901
- 902 Jaynes, J. 2009. *Provenance investigation of Tell Zeidan obsidian*, Poster presented in
903 the Dept. of Anthropology, College of Liberal Arts, California State University, Long
904 Beach.
- 905 Kainert, C. and P. Drechsler. 2014. An interplay of imports and local traditions? The pottery
906 assemblage from Dosariyah, Saudi Arabia. *Proceedings of the Seminar for Arabian Studies*
907 44: 213–226.
- 908 Keller, J., Djerbashian, R., Pernicka, E., Karapetian, S.G., Nasedkin, V. 1996. Armenian and
909 Caucasian obsidian occurrences as sources for the neolithic trade: Volcanological setting and
910 chemical characteristics. In: Ş. Demirci, A. M. Özer and G.D. Summers (eds): *Archaeometry*
911 94. *Proc. of the 29th Int. Symp. on Archaeometry*, 9-14 May 1994, Ankara, pp. 69-86.
- 912 Khalidi, L. 2014. 5th millennium BC obsidian production in area TW, Tell Brak. In *Preludes to*
913 *Urbanism: The Late Chalcolithic of Mesopotamia. Festschrift in Honour of Joan Oates*. A.
914 McMahon and H. Crawford (eds). McDonald Institute Monographs. Cambridge: McDonald Institute
915 for Archaeological Research, pp. 69-88.
916
- 917 Khalidi, L. and B. Gratuze 2013 Late Chalcolithic lithic assemblage at Tell Hamoukar's Southern
918 Extension. *Berytus 53-54* (2010-2011): 15-38.
919
- 920 Khalidi, L., B. Gratuze, M. Haidar-Boustani, J.J. Ibáñez and L. Teira. 2013. Results of
921 geochemical analyses of obsidian artifacts from the Neolithic site of Tell Labwe South,
922 Lebanon. In *Stone Tools in Transition: From Hunter-Gatherers to Farming Societies in the*
923 *Near East*. F. Borrell, J. J. Ibáñez and M. Molist (eds). Barcelona: Universitat Autònoma de
924 Barcelona, pp. 475-494.
925
- 926 Khalidi, L., B. Gratuze and S. Boucetta. 2009. Provenance of obsidian excavated from Late
927 Chalcolithic levels at the sites of Tell Hamoukar and Tell Brak, Syria. *Archaeometry* 51(6): 879-893.
928
- 929 Kallweit, H. and W. Davies. 2010. The Lithic Industries of H3. In R. Carter and H. Crawford
930 eds.: *Maritime Interactions in the Arabian Neolithic. Evidence from H3, As-Sabiyah, an*
931 *Ubaid-Related Site in Kuwait*. Leiden: Brill, pp. 105-128.
932
- 933 Le Bourdonnec, F.-X., G. Poupeau and C. Lugliè. 2006. SEM–EDS analysis of western
934 Mediterranean obsidians: a new tool for Neolithic provenance studies. *C. R. Geoscience* 338:
935 1150-1157.
936
- 937 Lugliè, C., F.-X. Le Bourdonnec, G. Poupeau, M. Bohn, S. Meloni, M. Oddone and G.
938 Tandraa. 2006. A map of the Monte Arci (Sardinia Island, Western Mediterranean) obsidian
939 primary to secondary sources: Implications for Neolithic provenance studies. *C. R. Palevol* 5:
940 995-1003.
941

- Masry, A.H. 1997. Prehistory in North Eastern Arabia. The Problem of Interregional Interaction. (Second edition). Kegan Paul, London.
- McMahon, A. 2014. State Warfare and Pre-state Violent Conflict: Battle's Aftermath at Late Chalcolithic Tell Brak. In *Preludes to Urbanism: The Late Chalcolithic of Mesopotamia. Festschrift in Honour of Joan Oates*. A. McMahon and H. Crawford (eds). McDonald Institute Monographs. Cambridge: McDonald Institute for Archaeological Research, pp. 175-188.
- McMahon, A. and Stone, A. 2013. Edge of the city: urban growth and burial space in 4th millennium BC Mesopotamia. *Origini* 35: 83-109.
- McMahon, A., Soltysiak, A. and Weber, J. 2011. Late Chalcolithic mass graves at Tell Brak, Syria, and violent conflict during the growth of early city-states. *Journal of Field Archaeology* 36/3: 201-220.
- McMahon, A. and Oates, J. 2007. Excavations at Tell Brak, 2006 & 2007. *Iraq* 69: 145-171
- Milano, L. and M. Lebeau (eds). 2014. *Tell Beydar: Environmental and Technical Studies. Volume II*. Brepols Publishers, Turnhout.
- Montigny, R., J. Tripier, Y. Besnus and M. -C. Cauvin. 1991. Nouvelles analyses d'obsidiennes du Proche-Orient : modèle de géochimie des magmas utilisé pour la recherche archéologique. *Paléorient* 17(2): 5-20.
- Pelegriin, J. 2012. New experimental observations for the characterisation of pressure blade production techniques. In *The Emergence of Pressure Blade Making. From Origin to Modern Experimentation*. P.M. Desrosiers (ed). New York, Dordrecht, Heidelberg, London: Springer, pp. 465-498.
- Pernicka, E. 1992. Herkunftsbestimmung späturukzeitlicher Obsidianfunde vom Hassek Höyük. In *Hassek Höyük – Naturwissenschaftliche Beiträge, Istanbulur Forschungen* 38. Behm-Blancke, M. (ed.). pp. 124–131.
- Poidevin, J.-L. 1998. Les gisements d'obsidienne de Turquie et de Transcaucasie: géologie, géochimie et chronométrie. In *L'obsidienne au Proche et Moyen Orient: du volcan à l'outil*. M. C. Cauvin, A. Gourgaud, B. Gratuze, N. Arnaud, G. Poupeau, J.-L. Poidevin and C. Chataigner (eds). BAR International Series 738 and Maison de l'Orient Méditerranéen, R. Makjanic (general ed). Oxford: Archaeopress, pp. 105-156.
- Poupeau, G., G. Bigazzi, L. Bellot-Gurlet and O. Dorighel. 1998. Fission-track dating of obsidians and archaeology. In *L'obsidienne au Proche et Moyen Orient: du volcan à l'outil*. M. C. Cauvin, A. Gourgaud, B. Gratuze, N. Arnaud, G. Poupeau, J.-L. Poidevin and C. Chataigner (eds). BAR International Series 738 and Maison de l'Orient Méditerranéen, R. Makjanic (general ed). Oxford: Archaeopress, pp. 53-67.
- Renfrew, C. and J. E. Dixon. 1976. Obsidian in western Asia: a review. In *Problems in Economic and Social Archaeology*. G. d. G. Sieveking, I. H. Longworth and K. E. Wilson (eds). London: Duckworth, pp. 137-150.

- 990 Renfrew, C., J. E. Dixon and J.R. Cann. 1966. Obsidian and Early Cultural Contact in the
 991 Near East. *Proceedings of the Prehistoric Society* 32: 30-72.
 992
- 993 Renfrew, C., J. E. Dixon and J.R. Cann. 1968. Further Analysis of Near Eastern Obsidians.
 994 *Proceedings of the Prehistoric Society* 34(9): 319-331.
 995
- 996 Stein, G. 2010. Local identities and interaction spheres: modeling regional variation in the
 997 Ubaid horizon in *Beyond the Ubaid. Transformation and Integration in the Late Prehistoric*
 998 *Societies of the Middle East*. Studies in Ancient Oriental Civilisation 63. Chicago: The
 999 Oriental Institute of the University of Chicago, pp. 23-44.
- 1000 Stein, G. 2010-2011. Tell Zeidan. *Oriental Institute Annual Report* 2010-2011: 121-138.
 1001
- 1002 Stein, G. 2012. The development of indigenous social complexity in Late Chalcolithic Upper
 1003 Mesopotamia in the 5th-4th millennia BC - an initial assessment. *Origini* XXXIV: 125-151.
 1004
- 1005 Stein, G. and A. Alizadeh. 2013-2014. Surezha, Kurdistan. *Oriental Institute Annual Report*:
 1006 138-151.
 1007
- 1008 Tykot, R. H. 1997. Characterization of the Monte Arci (Sardinia) Obsidian Sources. *Journal*
 1009 *of Archaeological Science* 24: 467-479.
 1010
- 1011 Ur, Jason. 2002. Settlement and Landscape in Northern Mesopotamia: The Tell Hamoukar
 1012 Survey 2000 - 2001. *Akkadica* 123 (2002): 57-88.
 1013
- 1014 Ur, J., Karsgaard, P., and Oates, J. 2007. Early urban development in the Near East. *Science* 317
 1015 (5842): 1188.
 1016
- 1017 Ur, J. A. 2010. *Urbanism and Cultural Landscapes in Northeastern Syria: The Tell*
 1018 *Hamoukar Survey 1999-2001*. Tell Hamoukar 1. Chicago: Oriental Institute Publications.
 1019
- 1020 Wilkinson, T. J. 2002. Physical and cultural landscapes of the Hamoukar area, (Syria).
 1021 *Akkadica* 123: 89-106.
 1022
- 1023 Wilkinson, T. J. and David J. Tucker. 1995. *Settlement Development in the North Jazira,*
 1024 *Iraq: A Study of the Archaeological Landscape*. Warminster: Aris and Phillips.
 1025
- 1026 Wright, Henry T. 2001. Cultural Action in the Uruk World. In *Uruk Mesopotamia and its*
 1027 *Neighbors: Crosscultural Interactions and Their Consequences in the Era of State*
 1028 *Formation*. M. S. Rothman (ed). Santa Fe (NM): School of American Research Press, pp.
 1029 123-148.
 1030
 1031

8. Figure and Table Captions

Table 1: Average compositions and standard deviations for artifact compositional groups; oxides are given in weight percent, elements are given in mg/kg. The number of samples attributed to each group is given in brackets. Empty cells in the table are due to the fact that some elements were not determined in early analyses. Nemrut Dağ (artifacts from Zeidan, Umm Dabaghyah, Arpachiyah, Kheit Qassim, Dosariyah, as-Sabiyah, Surezha, Khirbat-al-Fakhar, Brak and Majnuna), Bingöl B (artifacts from Zeidan, Khirbet Derek, Umm Dabaghyah, Khirbat-al-Fakhar, Brak and Majnuna), Bingöl A (artifacts from Zeidan, Umm Dabaghyah, Dosariyah and Wadi Debay'an), Meydan Dağ (artifacts from Zeidan, Kheit Qassim, Surezha, Khirbat-al-Fakhar, Brak and Majnuna), Pasinler (artifacts from Zeidan and Dosariyah), Sarikamiş North (artifacts from Surezha and Khirbat-al-Fakhar), Sarikamiş South (artifacts from Surezha and Brak)

Table 2: Number of obsidian artifacts analyzed per obsidian source match and per site for totality of sites featured

Table 3: Preliminary analysis of the obsidian assemblage from Tell Zeidan by context

Table 4: Breakdown of number of obsidian artifacts analyzed per source/period at Tell Zeidan

Table 5: Breakdown of number of obsidian artifacts analyzed per source/period at Surezha

Table 6: Breakdown of number of analyzed obsidian artifacts per source/period at Khirbat al-Fakhar

Table 7: Breakdown of number of analyzed obsidian artifacts per source/site area at Tell Brak (TW), Tell Majnuna (EM, EME, MTW) and T2

Table 8: Breakdown of number of analyzed obsidian artifacts per period at Tell Brak, Tell Majnuna, and T2

Table 9: Breakdown of number of analyzed obsidian artifacts per source/site from Halaf and Ubaid period sites (Khirbet Derek, Umm Dabaghiyah, Arpachiyah, Kheit Qassim III) in North Iraq

Table 10: Breakdown of number of analyzed obsidian artifacts per source/site from Ubaid 2/3 sites (Dosariyah, as-Sabiyah, Wadi Debay'an) in the Arabian Gulf

Figure 1: Map of obsidian sources and Halaf to Late Chalcolithic sites referenced (D. Mouralis, GeObs).

Figure 2: Binary diagram Fe vs. Zr showing source groups for studied artifacts: Arteni 2 (Zeidan), Arteni 3 (Brak), Bingöl A (Zeidan, Umm Dabaghyah, Dosariyah and Wadi Debay'an), Bingöl B (Zeidan, Khirbet Derek, Umm Dabaghyah, Khirbat-al-Fakhar, Brak and Majnuna), Erzincan (as-Sabiyah), Gegham and Gegham or Sjunik (Dosariyah), Meydan Dağ (Zeidan, Kheit Qassim, Surezha, Khirbat-al-Fakhar, Brak and Majnuna), Nemrut Dağ (Zeidan, Umm Dabaghyah, Arpachiyah, Kheit Qassim, Dosariyah, as-Sabiyah, Surezha, Khirbat-al-Fakhar, Brak and Majnuna), Pasinler (Zeidan and Dosariyah), Sarikamiş North (Surezha and Khirbat-al-Fakhar), Sarikamiş South (Surezha and Brak), 3D (Zeidan, Arpachiyah and Surezha).

Figure 3: Binary diagram of Y/Nb vs. Rb/Cs ratios for studied artifacts according to their source groups: Arteni 2 (Zeidan), Arteni 3 (Brak), Bingöl A (Zeidan, Umm Dabaghyah, Dosariyah and Wadi Debay'an), Bingöl B (Zeidan, Khirbet Derek, Umm Dabaghyah, Khirbat-al-Fakhar, Brak and Majnuna), Erzincan (as-Sabiyah, not represented), Gegham and Gegham or Sjunik (Dosariyah, one not represented), Meydan Dağ (Zeidan, Kheit Qassim, Surezha, Khirbat-al-Fakhar, Brak and Majnuna), Nemrut Dağ (Zeidan, Umm Dabaghyah, Arpachiyah, Kheit Qassim, Dosariyah, as-Sabiyah, Surezha, Khirbat-al-Fakhar, Brak and Majnuna), Pasinler (Zeidan and Dosariyah), Sarıkamiş North (Surezha and Khirbat-al-Fakhar), Sarıkamiş South (Surezha and Brak), 3D (Zeidan, Arpachiyah and Surezha).

Figure 4: Binary diagram Zr vs. Ba for artifacts originating from calalkaline obsidian sources: Arteni 2 (Zeidan), Arteni 3 (Brak), Bingöl B (Zeidan, Khirbet Derek, Umm Dabaghyah, Khirbat-al-Fakhar, Brak and Majnuna), Erzincan (as-Sabiyah), Gegham and Gegham or Sjunik (Dosariyah), Meydan Dağ (Zeidan, Kheit Qassim, Surezha, Khirbat-al-Fakhar, Brak and Majnuna), Pasinler (Zeidan and Dosariyah), Sarıkamiş North (Surezha and Khirbat-al-Fakhar), Sarıkamiş South (Surezha and Brak), 3D (Zeidan, Arpachiyah and Surezha).

Figure 5: Examples of cores, blades and splintered pieces from Tell Zeidan, various contexts.

Figure 6: Obsidian blade core measuring 12.4 cm in length and weighing 81.9 g featuring a crested back and an obliquely set striking platform from a Late Chalcolithic context in Operation 3 on the northeast mound of Tell Zeidan. Tell Zeidan archive.

Figure 7: Three blades, each made from obsidian with different macroscopic characteristics, recovered from excavations at Tell Zeidan. Tell Zeidan archive.

Figure 8: 100% stacked column graph of percentages of analyzed obsidian artifacts per source and per site for totality of sites and sources featured

Figure 9: 100% 3D stacked column graph of percentages of analyzed obsidian artifacts per source and per period for totality of sites and sources featured

Figure 10: Line graph of obsidian quantities (number of obsidian artifacts analyzed) by period/source for totality of sites and sources featured