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The Obsidian Industry at Bukit Tengkorak, Sabah, Malaysia

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INTRODUCTION

In 1994-95, archaeological research was undertaken by a joint Centre for Archaeological Research Malaysia and Muzium Sabah team at Bukit Tengkorak, a Neolithic site in Semporna, Sabah (Figure 1). Geologically, Bukit Tengkorak forms part of the rim of a 2 kilometre-wide volcanic crater, surrounded by numerous isolated hills and mountains, most of them representing sites of extinct volcanoes ranging from Pliocene to Quaternary in age (HD Tjia, personal communication, Kirk 1962, Lee 1970). Two seasons of excavations, over a period of 5 weeks, were carried out at two volcanic outcrops near the summit of Bukit Tengkorak, approximately 600 feet about sea level[1]. A total of 6-one metre trenches (G17, G19, J19, R36, S37, and T38), three in each outcrops, were excavated until the base of the undisturbed cultural deposits, about 150 cm in maximum depth (Figure 2). The excavated area covered about 10% of the total area that can be excavated. The top layer (0-20 cm) of trenches G17, G19, and J19 appeared to be disturbed but the subsequent layers contained undisturbed artefacts which were excavated in arbitrary controlled spits of 5 cm deep per spit or level. More than 6 cubic metres of soil was excavated and sieved through 1 mm and 0.2 mm meshes. A broad range of archaeological materials were recovered and they include large quantities of pottery sherds, chert and agate microliths, obsidian flakes, polished adzes, a bark cloth beater, and some shell or bone artifacts. The abundant food remains, mostly marine mollusks and fish bones (as well as some terrestrial animal bones) is indicative of a maritime-oriented society at Bukit Tengkorak.

Five radiocarbon dates place the site between 4300 BC and possibly 50 BC. All the radiocarbon dates are listed in Table 1. Four of the samples are charcoal and one (Beta-744448) is of Anadara shells. The charcoal samples were calibrated with the Stuiver INT93 Cal program (1993). Out of the five samples, one (Beta-744447) is modern, confirming that the top layers (0-20cm) of trench G17 is disturbed. As such, the absolute date for the last use of the site is still unknown but given the absence of metal artifacts, stonewares, and procelain at the top layers, the site is probably abandoned before 2000 BP or around 50 BC[2]. On the basis of the radiocarbon dates, soil stratigraphy, and the temporal distribution of artifact types, three occupational phases: Early Phase (4300-1200 BC); Middle Phase (1200-900 BC); and Late Phase (900-50 BC), were defined at Bukit Tengkorak.

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[1] Test excavations were done at Bukit Tengkorak in 1987 by Bellwood (1989) & Bellwood & Koon (1989)
[2] Despite the lack of a well-established date for the first use of metal in island Southeast Asia, a date of about 2,000 BP is generally accepted for the arrival of bronze and iron artifacts, particularly in Java, Bali, the Talaud islands, and Sabah (Soejono, 1979; Bronson and Glover, 1984; Bellwood, 1985).

Table 1: Radiocarbon dates from Bukit Tengkorak, Sabah

Lab #	Conventional Age (BP)	Calibrated Age (BC)*	Material	Notes
Beta-74447	101.0 ± 0.9%M	---	charcoal	Trench G17, layer 1 spit 4, 15-20cms
Beta-74448	3190 ± 60	1190 to 860**	*Anadara* shells	Trench G17, layer 3 spit 11, 50-55cms
Beta-83783***	2940 ± 50	1285 to 990	charcoal	Trench G17, layer 4 spit 15, 70-75cms
Beta-83784	2650 ± 90	980 to 745 700 to 530	charcoal	Trench G17, layer 5 spit 20, 95-100cms
Beta-83785	5330 ± 80	4340 to 3975	charcoal	Trench G17, layer 8 spit 26, 125-130cms

* Cal BC dates (2 sigma, 95% probability)

** This marine shell sample has been calibrated according to Stuiver & Braziunas (1993).

*** This sample was analysed using AMS (Lawrence Livermore).

THE OBSIDIAN INDUSTRY

A total of 552 obsidian artifacts, weighing about 145 grams, were recovered during our excavations at Bukit Tengkorak. The obsidian came in a variety of colors, translucency, luster, and texture; from very glassy, highly translucent, and black in color to less glassy, totally opaque, and grey in color. They occurred mostly in the form of tiny flakes, weighing below 5.6 grams and measuring under 2 cm in maximum dimension (Figure 3). The obsidian assemblage were classified into core fragments (3%), utilised flakes (27%), retouched flakes (6%), and waste flakes (64%) -Figure 4, Tables 2 & 3.

The flaking technology was directed at producing very small flake tools instead of blades. This is evident from the large number of utilised and retouched pieces. Only a small percentage (14%) of these utilised or retouched pieces may be considered blades, with their length/width ratio exceeding 2. The lack of negative blade scars on the core fragments also indicates that the cores were not originally designed to produce blades. The majority of the utilised or retouched pieces are very small, averaging about 1.1 mm in length and about 0.3 grams in weight. It is most probable that these pieces need to be hafted as they would be too small to be manipulated solely by hand. Some of the retouched flakes have secondary flake scars along the sides and ends of the flake.

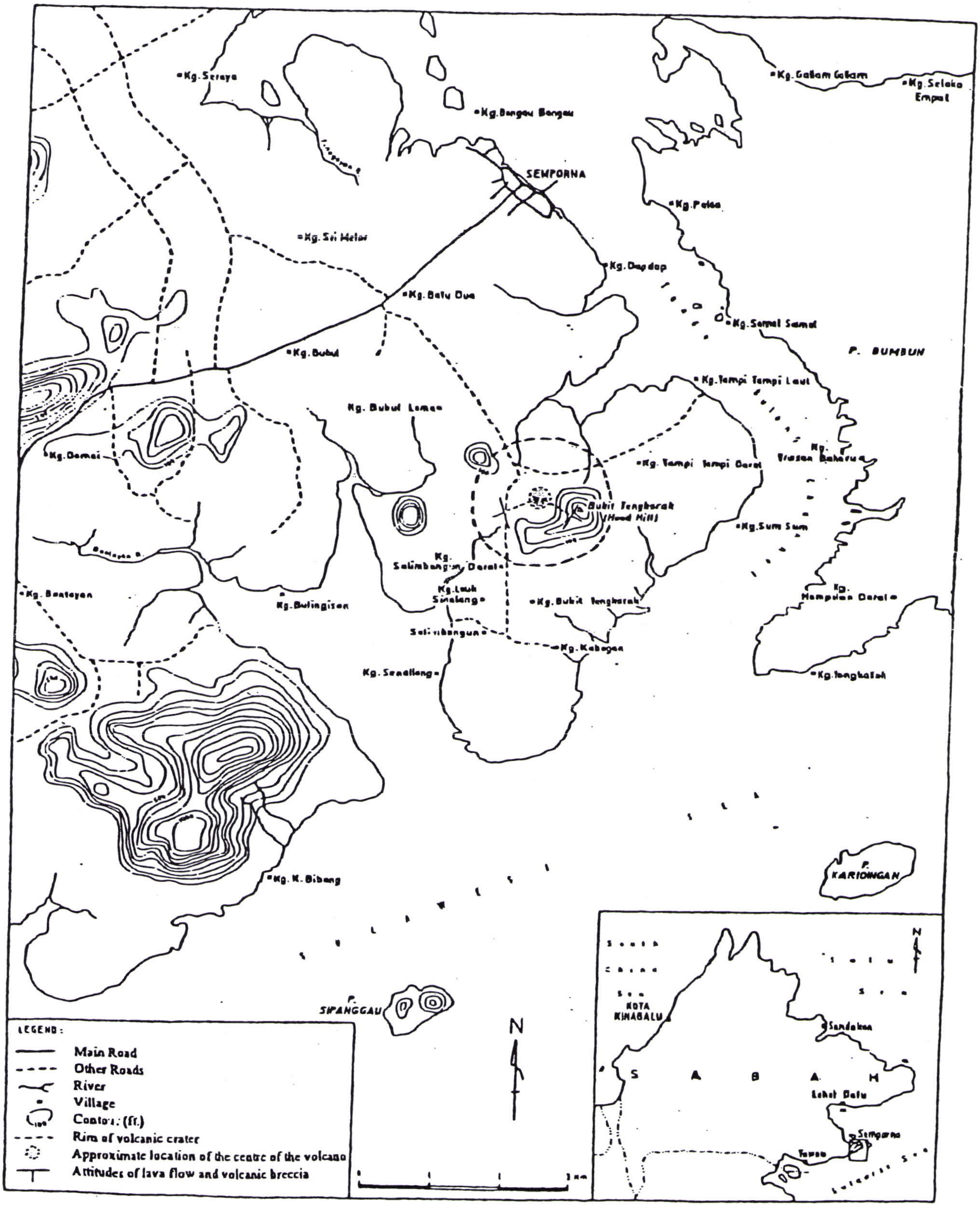

Figure 1: Map of Bukit Tengkorak in Semporna, Sabah

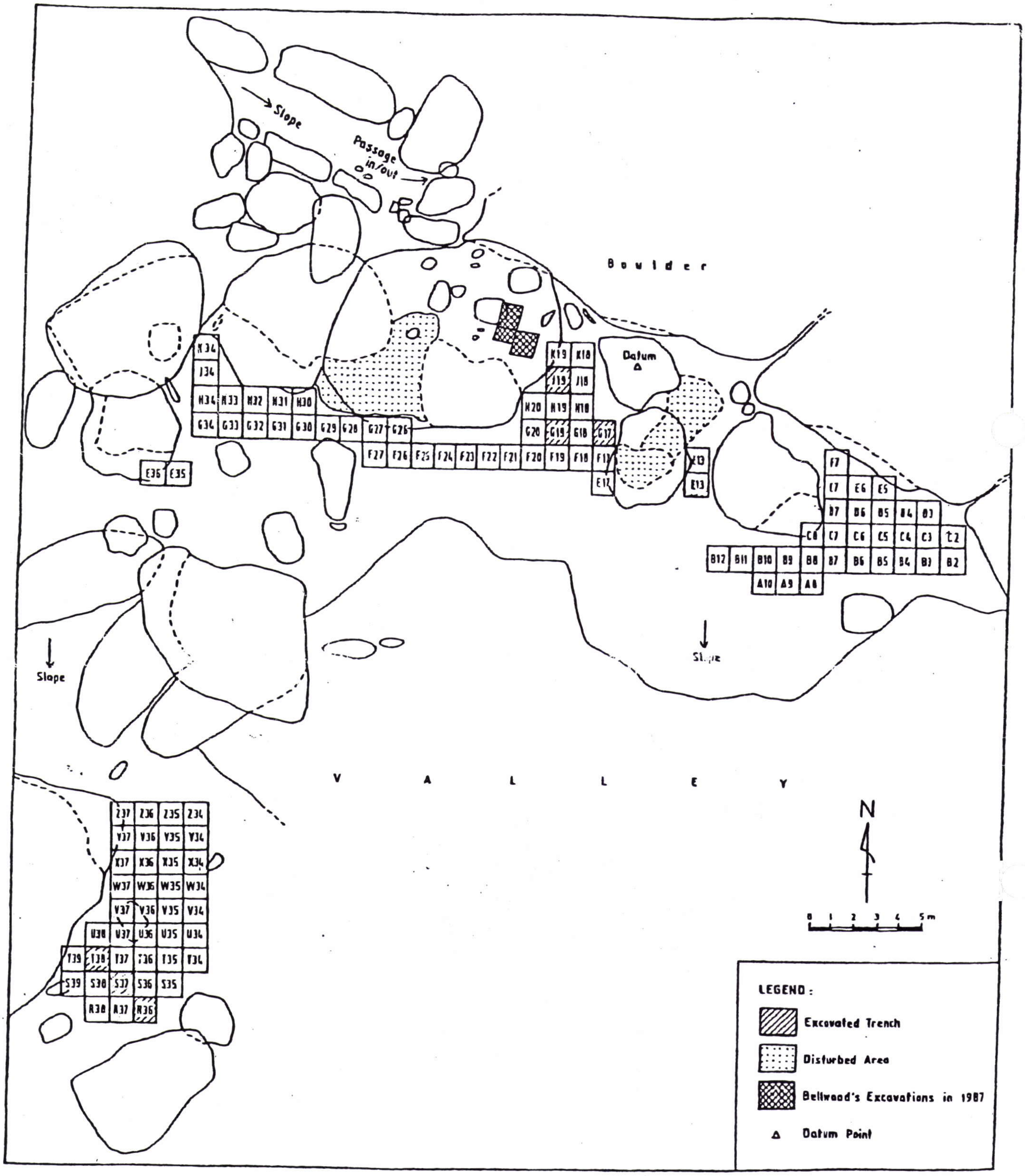

Figure 2: Plan of Bukit Tengkorak and the excavated trenches

The majority of the waste flakes are block-fractured flakes (72%) while the rest were conchoidal flakes (28%). The conchoidal flakes have closely similar butt thicknesses, averaging about 0.27 mm, showing consistency in flake removals. A large number of the retouched and utilised pieces (60%) were made of block-fractured flakes (although these flakes are less prefered by most toolmakers). The low frequency of cortical flakes (4.5%) suggested that the cores had their cortexes removed, probably before they were brought to the site. The core fragments are very small, measuring less than 2.5 cm in maximum diameter and weighing not more than 5.61 grams. All these plus the small amount of obsidian (145 grams) recovered during the excavations seem to indicate that obsidian is scarce and hence the desire to make full use of this exotic and valuable material.

OBSIDIAN SOURCES

During our 1994-95 excavations, geological surveys were carried out in and around the Semporna Peninsula but no sources of obsidian were found. Since obsidian is known to be widely exchanged or traded over long-distances during the Lapita period (1600 BC) in the southwest Pacific, it was decided that a sourcing study be carried out to see if the origins of the obsidian artifacts can be traced to any of the 66 known sources in the southwest Pacific and some Indonesian islands which have been chemically characterized and catalogued by J.R. Bird and his colleagues (Bird *et al.* 1978, Duerden *et al.* 1980, Bird *et al.* 1981a, 1981b, Smith *et al.* 1977, Ambrose *et al.* 1981, Summerhayes *et al.* 1993). Over the last 20 years or so, research in the southwest Pacific had also shown that allocating obsidian artifacts to geographical sources can be successfully done using a variety of elemental analysis (Smith *et al.* 1977, Bird *et al* 1981a, 1981b, Smith 1982, Duerden *et al.* 1987, Green 1987).

Obsidian Analysis: A total of 30 of the 552 pieces of obsidian artifacts excavated from Bukit Tengkorak were analysed using a fully automated Cameca MBX electron microprobe with wavelength dispersive X-ray spectrometers at the Department of Earth and Planetary Sciences at Harvard University. These pieces were selected from obsidian artifacts recovered from the undisturbed spits 12 to 26 (60-130 cm) in trenches G17 and J19, radiocarbon dated to between 900 and 4300 BC. Obsidian artifacts with different visible characteristics such as color, translucency, luster, and texture, that might indicate different sources, were selected. This is also done in order to reduce sample bias toward selecting obsidian pieces produced from a single piece of core. Based on all these criteria, a total of 30 samples; 15 from trench G17 and another 15 from trench J19, were selected for analysis. The electron microprobe analysis was chosen as a method of choice mainly because it is minimally destructive (only 1 mm size sample is needed) and is a relatively fast and accurate method (1-2% accuracy) for determining the selected range of elements within the required detection limits of 0.01 to 0.1 weight percent, depending upon the element and composition of the sample. The selected range of elements are namely Si, Al, Fe, Mg, Ca, K, P, Mn, and Ba. These elements are among the most distinctive elements that have been found to be useful in distinguishing the 66 known obsidian sources in the Pacific and its neighbouring regions (Green and Bird 1989: 92).

Results and Discussion: The results of the electron microprobe analysis show three different compositional groups, suggesting that the artifacts were made using obsidian obtained from three different sources. The microprobe data are presented in Table 4. Two dimensional x-y cluster analysis is also used to examine the data using combinations of two different oxides. The results reveal at least three distinct compositional groups (Figure 5). Another noteworthy observation from this study is that each of the two main compositional groups, A and B, contained obsidian samples with distinct visual types. In group A, all the obsidian samples are generally very glassy, highly translucent, and black in color while group B has obsidian that are less glassy, less traslucent, and grey to black in color. The single sample in Group C is less glassy, totally opaque, and black in color.

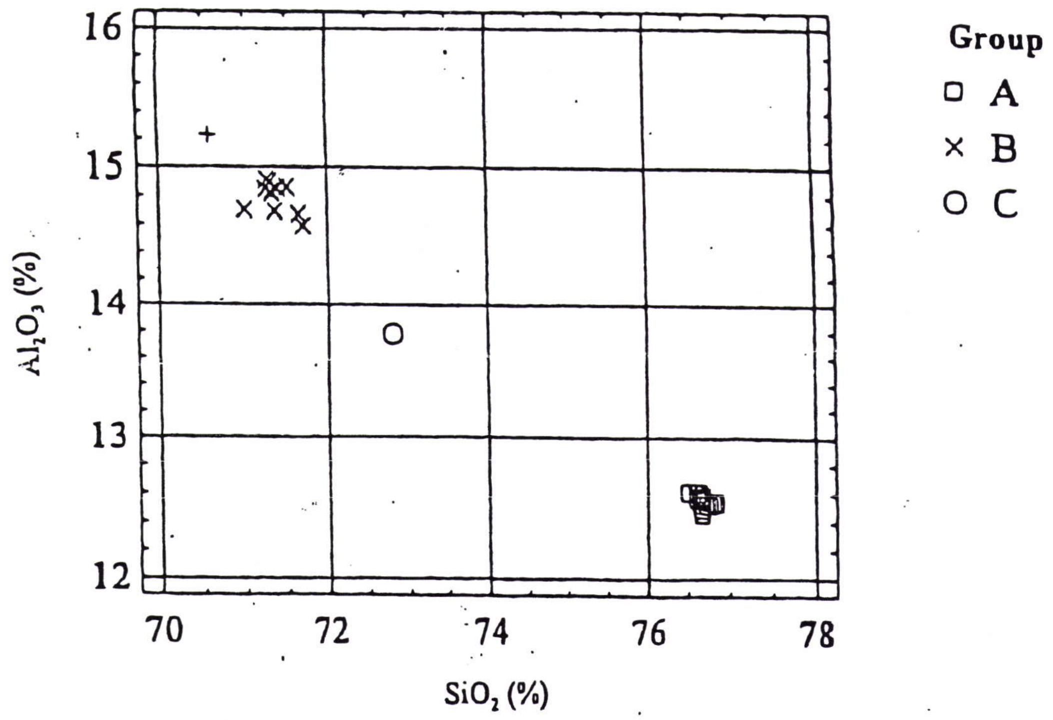

Figure 5 : Plot Of Al_2O_3 vs SiO_2 Of Obsidian Artefacts From Bukit Tengkorak

The three compositional groups were then carefully compared with the database of 66 known sources in the Pacific and the neighbouring regions. Based on the weight percent value of eight elements (Si, Al, Ti, Fe, Ca, Na, K, and Mn), each of the compositional groups were compared with corresponding elemental weight percent values of the 66 known sources presented by Duerden *et al.* (1987, Table 1) and a recent updated catalogue on Pacific obsidian source composition provided by Dr. Roger Bird.

The results of the comparisons showed that compositional group A matches chemically with the Kutau/Bao sub-source at Talasea in New Britain, western Melanesia. Group B matches the few obsidian artifacts from the Talaud islands, for which no geological source has yet been identified. The single obsidian artifact representing group C appears to match obsidian sources in the Admiralty Islands (Solang, Umrei, and Wekwok).

In terms of stratigraphic levels, the majority (15 pieces or 88%) of the Talasean obsidian come from the upper levels 12-19 while most (8 pieces or 64%) of the group B (Talaud artifact group) come from the lower levels 23-26. Chronologically, this change in the relative importance of obsidian sources with time seems to suggest that the unknown obsidian source represented by group B (Talaud artifact group) was an important obsidian source at around 4300 BC but became less important at around 1200-900 BC. The Talasea source, on the other hand, appears to be important from 1200 to 900 BC.

CONCLUSIONS

Our research shows that the prehistoric inhabitants of Bukit Tengkorak obtained obsidian from three different sources at around 4300 to 900 BC to produce small flake tools. The majority of the obsidian artifacts, dated around 900-1200 BC, originated from the Kutau/Bao sub-source in Talasea, New Britain. This connection, over a distance of about 3500 km, not only represents the longest traded obsidian in the world for this time period but shows the existence of long-distance sea trading networks which extended in a westward direction from Melanesia to as far as Borneo in Southeast Asia. The most intriguing question arises as to the possible source of the obsidian artifacts, dated between 4300 to 1200 BC at Bukit Tengkorak, which matches a few artifacts from the Talaud Islands but have yet to be traced to any geological source. Since no obsidian sources are known in Borneo, the presence of obsidian earlier than 1600 BC at Bukit Tengkorak implies that advance seafaring trading networks could have existed in island Southeast Asia at least 2500 years prior to the Lapita period. It also opens up the possibility of an early trading system as early as 4300 BC between Southeast Asia and Melanesia.

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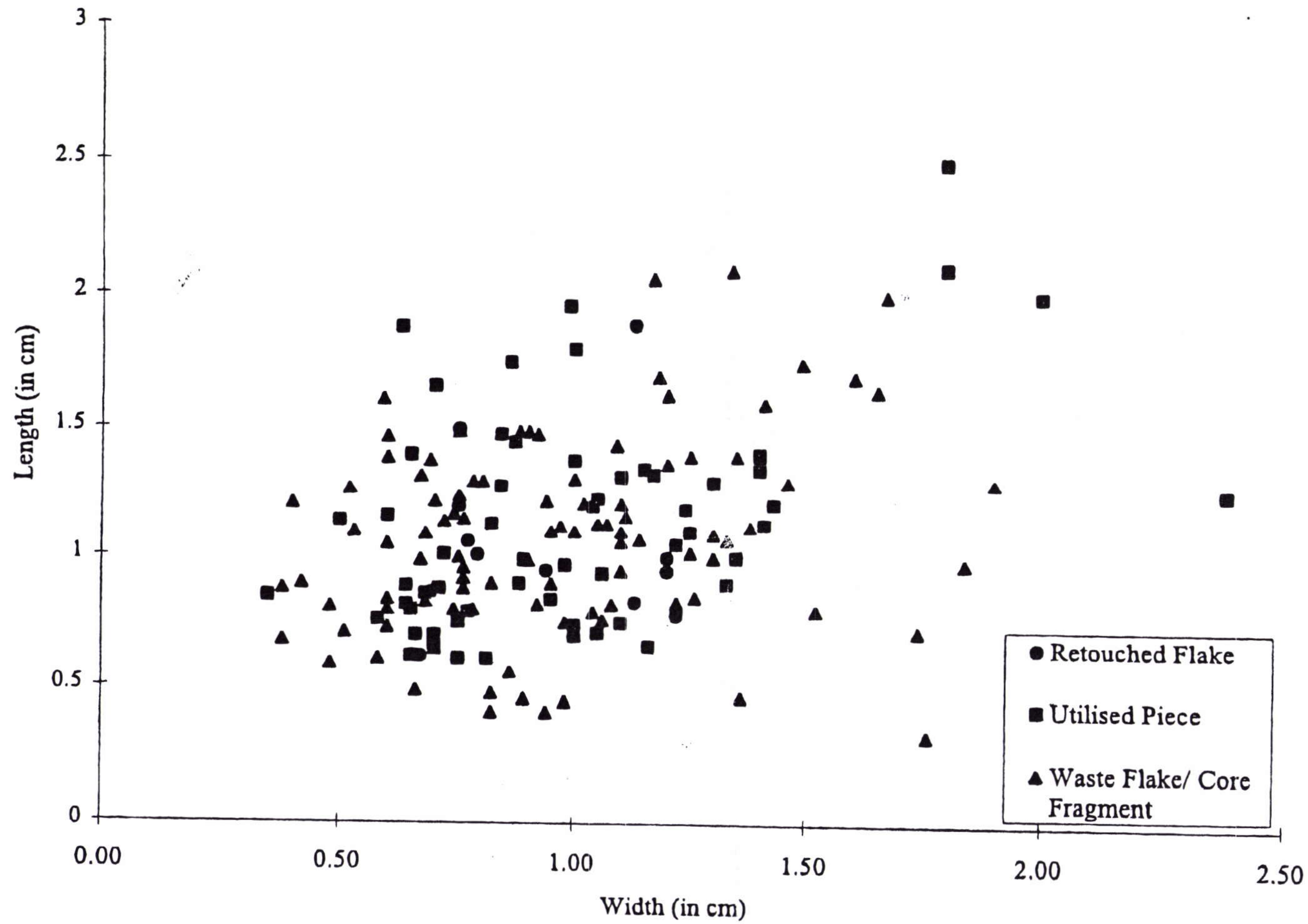


Figure 3 : Scatter Plots Of Length And Width For Obsidian Samples (Conchoidal Flakes) From Bukit Tengkorak

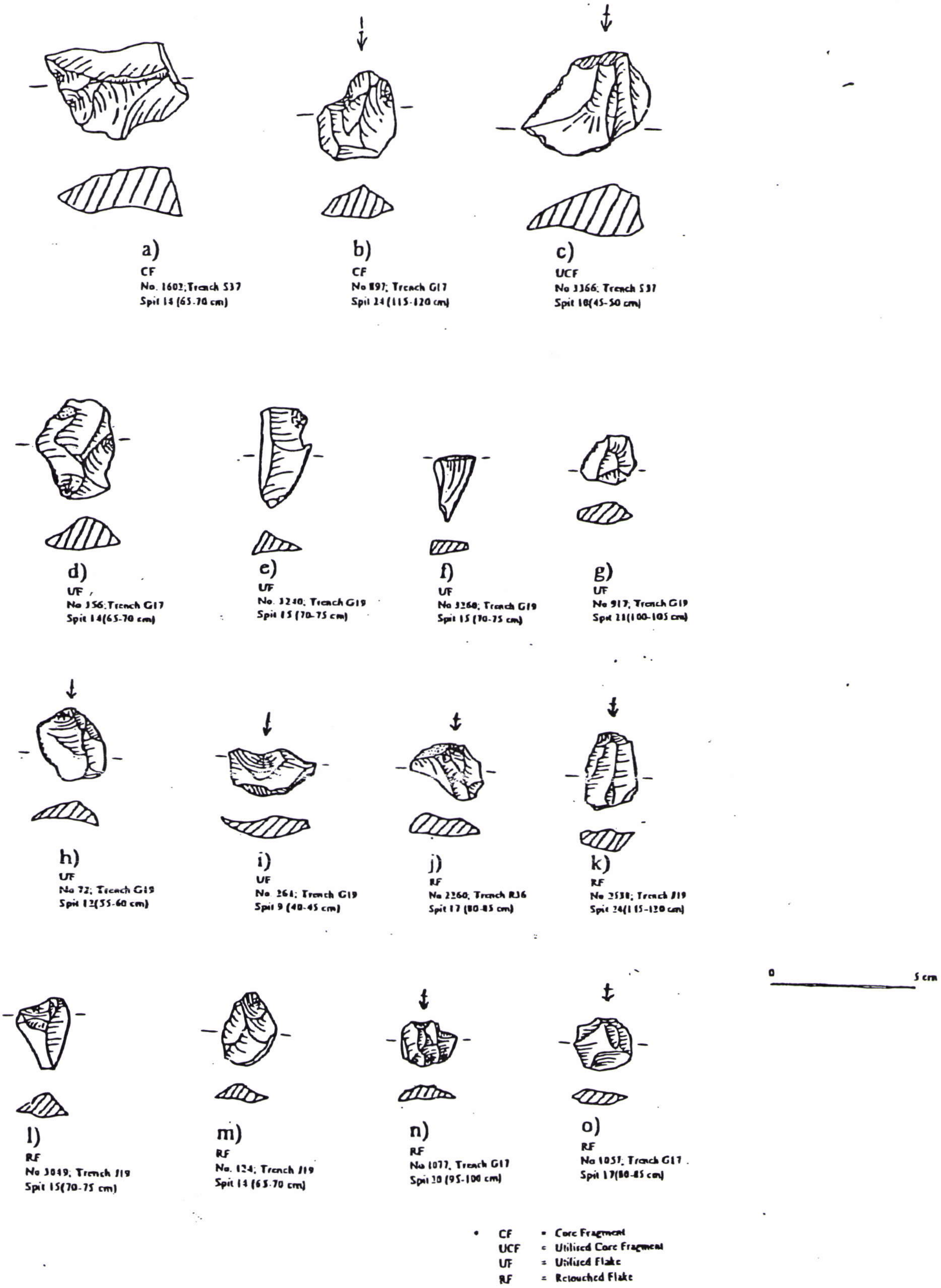


Figure 4 (a-o): Obsidian Artefacts

Table 2 : Vertical Distribution Of Obsidian In Trenches G17, G19 And J19

Spit	Class *						Total	
	UF	UCF	UFF	RF	CF	WF	No.	%
1	2	-	-	-	-	-	2	0.46
2	1	-	-	-	-	-	1	0.23
3	1	-	-	-	-	-	1	0.23
4	-	-	-	-	-	-	0	0.00
5	-	-	-	-	-	-	0	0.00
6	-	-	-	-	-	-	0	0.00
7	1	-	-	-	-	-	1	0.23
8	-	-	-	-	-	-	0	0.00
9	1	-	-	1	-	-	2	0.46
10	1	-	1	-	-	-	2	0.46
11	3	-	-	-	-	3	6	1.39
12	8	-	1	2	-	30	41	9.47
13	5	-	1	-	-	14	20	4.62
14	7	1	3	2	1	27	41	9.47
15	13	2	2	2	4	32	55	12.70
16	6	-	3	1	1	41	52	12.01
17	9	1	1	4	1	20	36	8.31
18	4	1	3	2	2	15	27	6.24
19	4	1	1	2	-	24	32	7.39
20	5	-	1	1	-	15	22	5.08
21	6	-	1	-	-	17	24	5.54
22	5	-	-	2	1	10	18	4.16
23	1	-	-	1	-	5	7	1.62
24	7	1	2	3	1	23	37	8.55
25	-	-	-	-	-	2	2	0.46
26	1	-	-	-	-	1	2	0.46
27	-	-	-	-	-	-	0	0.00
28	-	-	-	-	-	2	2	0.46
Total	91	7	20	23	11	281	433	100.00
%	21.02	1.62	4.62	5.31	2.54	64.90	100.00	

* Class:

UF	Utilised Flake	RF	Retouched Flake
UCF	Utilised Core Fragment	CF	Core Fragment
UFF	Utilised Flake Fragment	WF	Waste Flake

Table 3 : Vertical Distribution Of Obsidian In Trenches R36, S37 And T38

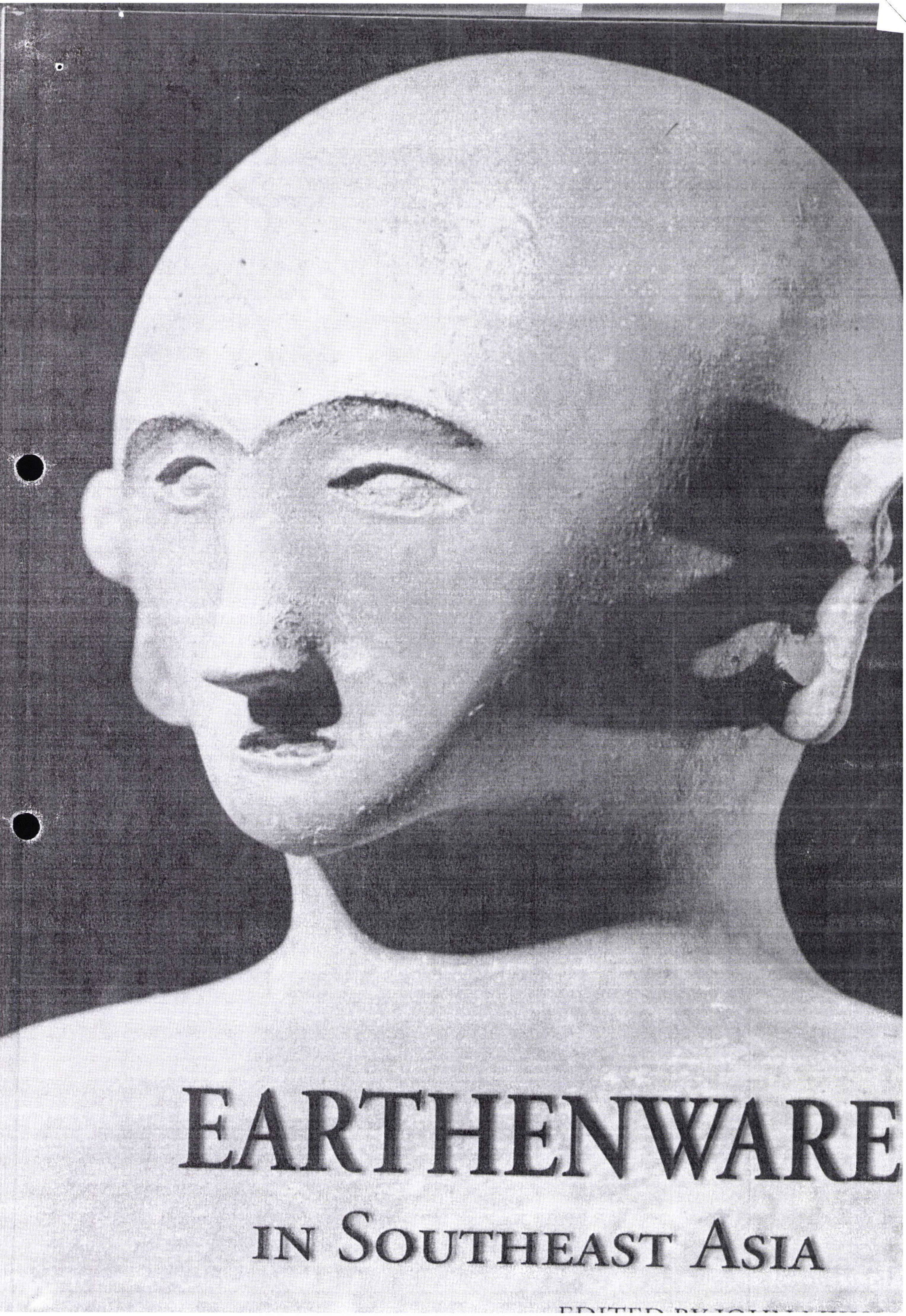
Spit	Class *						Total	
	UF	UCF	UFF	RF	CF	WF	No.	%
1	1	-	-	-	-	-	1	0.84
2	-	-	-	-	-	-	0	0.00
3	-	-	-	-	-	-	0	0.00
4	-	-	-	1	-	-	1	0.84
5	-	-	-	-	-	-	0	0.00
6	2	-	-	-	1	-	3	2.52
7	-	-	-	-	-	1	1	0.84
8	-	-	-	1	-	-	1	0.84
9	2	-	-	-	-	3	5	4.20
10	6	1	2	-	1	10	20	16.81
11	-	-	1	1	-	9	11	9.24
12	2	-	1	1	2	15	21	17.65
13	2	-	-	1	-	5	8	6.72
14	1	-	-	-	2	6	9	7.56
15	5	-	-	2	-	19	26	21.85
16	3	-	-	-	-	6	9	7.56
17	-	-	-	2	-	1	3	2.52
Total	24	1	4	9	6	75	119	100.00
%	20.17	0.84	3.36	7.56	5.04	63.03	100.00	

* Class:

UF	Utilised Flake	RF	Retouched Flake
UCF	Utilised Core Fragment	CF	Core Fragment
UFF	Utilised Flake Fragment	WF	Waste Flake

Table 4 Electron microprobe data for obsidian samples from Bukit Tengkorak

Group	Sample	Level	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O3	MnO	BaO	Total
A	J19/445	12	76.63	12.5	0.22	1.22	0.22	1.17	3.97	3.88	0.05	0.06	0.08	100
A	J19/411	12	76.78	12.54	0.23	1.19	0.21	1.14	3.9	3.89	0.02	0.05	0.04	100
A	J19/408	12	76.72	12.56	0.23	1.22	0.22	1.13	3.91	3.88	0.03	0.05	0.05	100
A	J19/135	12	76.77	12.56	0.24	1.17	0.22	1.12	3.87	3.9	0.03	0.05	0.07	100
A	J19/3606	12	76.66	12.54	0.22	1.25	0.22	1.17	3.88	3.92	0.05	0.05	0.05	100
A	G17/21	13	76.72	12.57	0.23	1.15	0.22	1.16	3.89	3.88	0.03	0.06	0.08	100
A	G17/356	14	76.66	12.54	0.22	1.26	0.22	1.16	3.85	3.93	0.04	0.05	0.07	100
A	J19/342	14	76.61	12.6	0.22	1.21	0.22	1.15	3.85	3.96	0.04	0.04	0.09	100
A	J19/354	14	76.81	12.49	0.23	1.23	0.22	1.13	3.87	3.88	0.04	0.06	0.04	100
A	G17/3133	15	76.66	12.57	0.22	1.23	0.23	1.16	3.87	3.91	0.04	0.07	0.02	100
A	G17/3130	15	76.75	12.5	0.22	1.2	0.22	1.16	3.86	3.9	0.04	0.06	0.07	100
A	G17/2637	17	76.69	12.58	0.24	1.19	0.22	1.14	3.84	3.92	0.05	0.06	0.08	100
A	G17/2636	17	76.7	12.54	0.23	1.24	0.22	1.15	3.87	3.87	0.03	0.06	0.07	100
A	G17/1240	18	76.65	12.51	0.22	1.25	0.22	1.15	3.88	3.94	0.03	0.06	0.07	100
A	G17/2403	19	76.73	12.52	0.23	1.24	0.22	1.16	3.86	3.86	0.03	0.06	0.08	100
A	G17/928	22	76.57	12.53	0.23	1.23	0.22	1.16	3.95	3.92	0.03	0.06	0.09	100
A	J19/2539	24	76.75	12.45	0.22	1.22	0.22	1.13	3.94	3.89	0.04	0.05	0.07	100
Mean			76.7	12.54	0.23	1.22	0.22	1.15	3.89	3.9	0.04	0.06	0.07	100
sd			0.06	0.04	0.01	0.03	0	0.01	0.04	0.03	0.01	0.01	0.02	0
B	J19/369	14	71.64	14.68	0.19	1.78	0.1	0.77	4.94	5.76	0.02	0.11	0	100
B	J19/3261	15	71.26	14.91	0.21	1.69	0.1	0.79	5.06	5.86	0.03	0.08	0	100
B	G17/3112	16	71.25	14.85	0.2	1.83	0.1	0.8	5.02	5.81	0.03	0.11	0.01	100
B	G17/1231	18	71.31	14.84	0.2	1.8	0.11	0.79	5.01	5.8	0.03	0.1	0.02	100
B	J19/3215	23	70.58	15.23	0.25	1.73	0.13	0.83	5.19	5.93	0.03	0.09	0	100
B	J19/3199	23	71.36	14.69	0.2	1.9	0.1	0.79	5.02	5.81	0.03	0.09	0.01	100
B	J19/2538	24	71.7	14.59	0.18	1.9	0.09	0.8	4.93	5.66	0.01	0.1	0.02	100
B	G17/2648	24	71.36	14.79	0.21	1.8	0.1	0.79	4.96	5.84	0.02	0.11	0.02	100
B	G17/949	24	71.32	14.82	0.2	1.82	0.1	0.78	5.01	5.82	0.02	0.11	0.01	100
B	J19/2521	24	71.39	14.85	0.21	1.76	0.1	0.78	4.92	5.87	0.02	0.09	0	100
B	G17/2151	25	71.3	14.9	0.21	1.73	0.09	0.76	4.98	5.9	0.03	0.1	0.01	100
B	G17/1383	26	71.5	14.86	0.2	1.8	0.1	0.79	4.99	5.83	0.02	0.1	0.01	100
Mean			71.33	14.83	0.21	1.8	0.1	0.79	5	5.82	0.02	0.1	0.01	100
sd			0.27	0.15	0.02	0.06	0.01	0.02	0.07	0.06	0	0.1	0.01	0
C	J19/3049	15	72.8	13.78	0.3	2.44	0.24	1.14	4.98	4.13	0.04	0.06	0.08	100



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