A COMPARISON OF SILICEOUS MUDSTONE ARTIFACTS FROM THE BIRIMI SITE (GHANA) USING INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS

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Abstract

The Birimi Site is located in the Northern Region of Ghana, a few kilometres from the Gambaga Escarpment. Excavation and survey during the 1996 and 1997 field seasons revealed that there are at least three components widely separated in time represented at Birimi. These include an Iron Age component (1,000-1,500 B.P.), a Kintampo component (2,500-4,000 B.P.) and a Middle Stone Age (MSA) component (ca. 30,000-40,000 B.P.). Chronometric dates on a variety of materials support this framework. During both the Kintampo and MSA occupations of the site, siliceous mudstone was used as a raw material for chipped stone artifacts. Stone tools and debris from the two occupations can be distinguished based on lithic production technology as well as on the degree of patination. A raw material outcrop has been discovered about 25 km from the site. No closer outcrops are known. Instrumental Neutron Activation Analysis (INAA) was employed to examine two issues. Was the same raw material source used by both Kintampo and MSA peoples? Are Kintampo or MSA artifacts from Birimi chemically similar to mudstone from the known outcrop?

Résumé

Le site de Birimi se trouve dans le Nord du Ghana, à quelques kilomètres de I'escarpement de Gambaga. Les fouilles et les relevés effectués au cours des campagnes do 1996 et de 1997 ont montré qu'au moins trois phases culturelles séparées par de longues périodes sont représentées à Birimi. Une de ces phases remonte à l'Âge du fer (1000-1500 A.A.), une au complexe de Kintampo (2500-4000 A.A.) et une au Mésolithique (v. 30000-40000 A.A.). La datation chronométrique de différents matériels corrobore ce cadre hypothétique. Au cours des occupations Kintampo et mésolithique du site, le mudstone siliceux était la matière première dont on fabriquait les objets de pierre taillée. Les outils et débris de pierre des deux périodes d'occupation se distinguent par la technologie de production lithique ainsi que par le degré de patine. On a découvert un affleurement de cette matière première à quelque 25 km du site. On n'en connaît pas de plus proche. Deux questions out éré étudiées grâce à l'analyse instrumentale par activation neutronique. Les peuples du Kintampo et ceux du Mésolithique utilisaient-ils la même matière première? Les objets du complexe de Kintampo et du Mésolithique trouvés sur le Birimi sont-ils analogues au point de vue chimique au mudstone de l'affleurement connu?

Introduction

The Birimi Site is a multi-component site in the Northern Region of Ghana with Iron Age, Kintampo and Middle Stone Age (MSA) occupations represented. Both Kintampo and MSA site inhabitants used siliceous mudstone as a raw material. This study is a comparison of the chemistry of siliceous mudstone artifacts from these two components using Instrumental Neutron Activation Analysis (INAA). The results show that there are differences between the two groups of artifacts that are consistent with weathering. Additionally, the chemistry of the artifacts was compared with samples from the closest known geological outcrop of siliceous mudstone. It falls within the range of variation of the chemistry of samples from the

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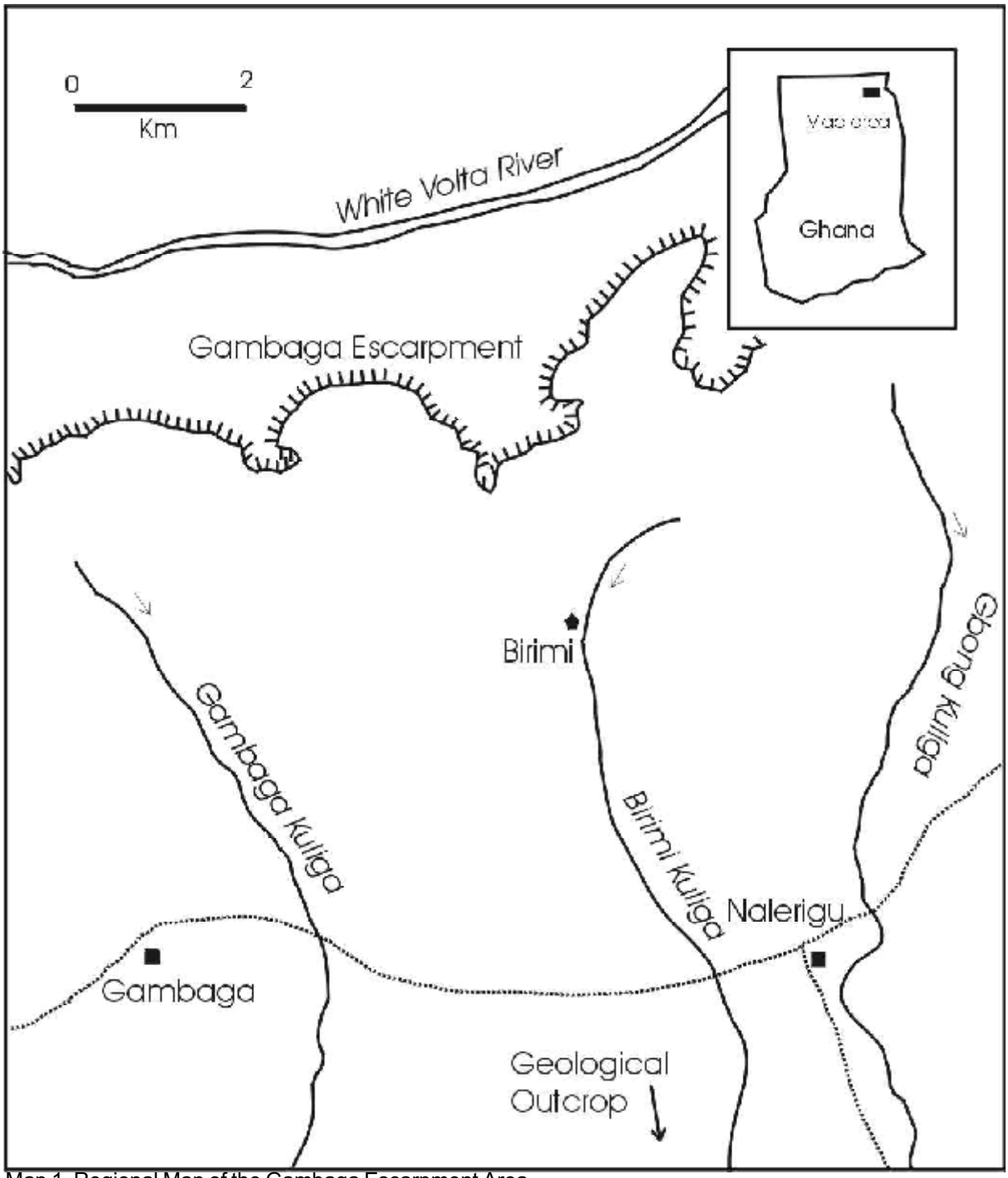


Map 1. Regional Map of the Gambaga Escarpment Area

outcrop, indicating that this place could have been used as a source of raw material. This does not exclude the possibility that raw material was obtained from a different outcrop location within the same geological formation.

Since 1996, Joanna Casey has led investigations of the Birimi Site in Northern Ghana (Casey *et al*. 1997). Research has focussed on the Kintampo component of the site, with limited investigation of the

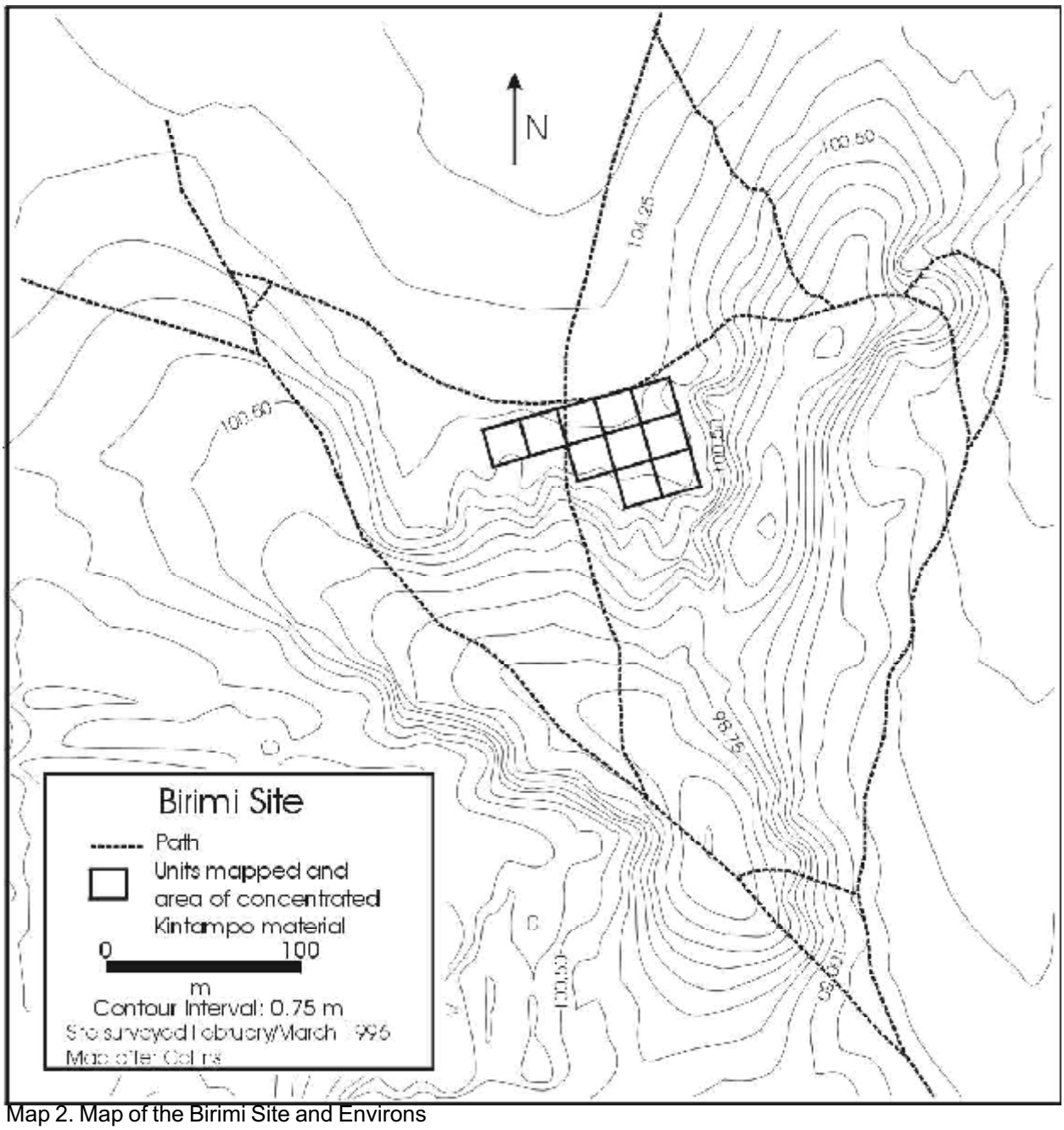
MSA and Iron Age material (Casey *et al.* 1997, D'Andrea *et al*. 2001, Godfrey-Smith *et al*. 1997, Hawkins *et al.* 1996). This paper outlines the background to the site and its setting before turning to a discussion of the INAA analysis, sampling, analytical methodology and results. The concluding section considers future research potential for examination of raw material sources used in the Gambaga region of northern Ghana.

Site Setting

The Birimi site is located approximately 3 km south of the Gambaga Escarpment, 3.5 km northwest of Nalerigu village (Map 1). It lies on Voltaian Formation sandstone that is exposed locally nearby, but is covered by deep sediments at the site and in most of the region. Godfrey-Smith has conducted preliminary examination of sediments and indicates that they are locally derived from a well-sorted, medium to coarse, heavily oxidized sandstone. Detailed description can be found in Hawkins *et al.* (1996). Although sediments mask the bedrock near the site, sandstone, siltstone and mudstone of the Voltaian Formation are exposed in the Gambaga Escarpment north of the site.

The site lies at the southern edge of the sudan savanna, but because of the high elevation of the Gambaga Escarpment, the local environment is a wooded savanna. The dry season is about five months long. During the Kintampo occupation of the site, the climatic conditions were probably at least as humid as today, if not somewhat wetter (Casey 2000). At this time it is impossible to comment on the climate and resources available during the MSA occupation because its dating is still very general. It is possible that the resources available during the MSA and Kintampo occupations, including exposed stone sources, were quite different.

The Birimi site lies on a terrace above the seasonal stream from which it takes its name (Map 2). Artifacts have been found in archaeological context and redeposited. MSA and Kintampo artifacts are found at the site in both geological and redeposited contexts. Redeposited artifacts are found on the surface of the site, on the gentle incline of the terrace above the stream bed, on the stream banks and on the alluvial surface below. Excavations have shown that the strata that contain the Kintampo period occupation levels are complicated by episodes of digging, construction and destruction, and possibly by multiple occupations as well. Artifacts and cultural layers are also visible in the eroding stream banks. The MSA material is found in context approximately one metre below the surface. In the eroding stream banks, MSA materials are found well below the Kintampo levels. Occasionally, MSA artifacts have been found in levels associated with the Kintampo occupation. This is attributed primarily to mixing that resulted from Kintampo digging activity, rather than to use of MSA artifacts by Kintampo people. Reworked MSA pieces are found, albeit rarely, at this and other Kintampo sites. However, there is no evidence that the MSA pieces found at Birimi in Kintampo contexts were systematically reworked for use as chipped stone tools. This does not exclude the possibility that MSA artifacts were regularly used by Kintampo people for other purposes, such as chinking in walls. Digging activities may also explain, in part, the presence of MSA artifacts on the terrace surface at an elevation higher than the elevation they are found at archaeologically. It is also possible that the MSA surface material has been transported by geological agents from elsewhere.



Map 2. Map of the Birimi Site and Environs

Chronology

Several approaches have been taken in dating the Kintampo and Iron Age occupations of the site. Charcoal and charred seeds have been radiocarbon dated (D'Andrea *et al*. 2001, Godfrey-Smith *et al*. 1997); burnt daub has been dated using thermoluminescence (Godfrey-Smith *et al*. 1997); and sediments have been dated using optically stimulated luminescence (OSL) (Quickert 1998). These determinations indicate a Kintampo occupation between 3000 and 4000 B.P, which is consistent with other chronometric determinations from sites elsewhere in Ghana (Casey 1998:86).

The MSA occupation has been dated by OSL of sediments (Quickert 1998). Three determinations on sediments associated with the MSA at Birimi are considered to be statistically indistinguishable and suggest

an age of ca. 30,000 BP for the MSA occupation of Birimi (Quickert 1998). In the larger context of the chronology of the African MSA, these dates should be considered quite late. Equivalent dates for the Later Stone Age (LSA) from the Central African site Shum Laka (Cornelissen 1996), indicate that in this region, the chronological relationship between the LSA and MSA may not be straightforward.

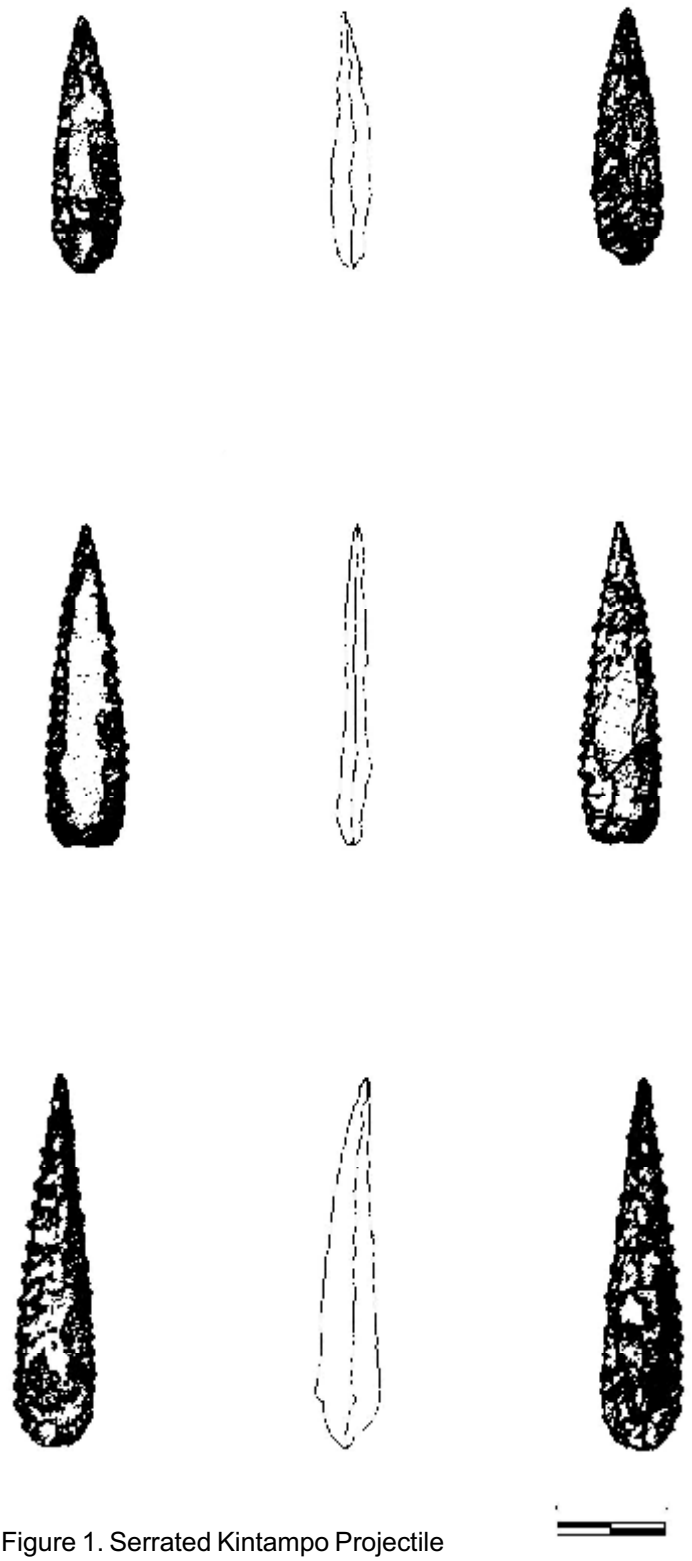


Figure 1. Serrated Kintampo Projectile Points

Cultural Material

The Birimi site is unusual in Northern Ghana because of the excellent preservation of plant remains and building materials associated with the Kintampo occupation, and a rich assemblage of artifacts in primary context. The charred plant remains are abundant and a floatation program has resulted in evidence for the earliest domesticated millet *(Pennisetum glaucum)* in West Africa (D'Andrea *et al*. 2001). This provides the first good evidence for cultivation of plants during the Kintampo period. The artifact assemblage from the Kintampo contexts at Birimi includes a variety of chipped and ground stone artifacts on quartz, siliceous mudstone, greenstone, sandstone and laterite; pottery; and burnt daub. Sawatzky (1998) has analysed the burnt daub, and analyses of the lithic material and pottery are ongoing (Carriere 2000, Casey 2000).

The MSA artifact assemblage consists solely of chipped stone artifacts, many or all of which are of siliceous mudstone. Occasional large quartz flakes found on the surface cannot be identified definitively as MSA, but are technologically consistent with MSA siliceous mudstone artifacts. Most MSA material recovered to date comes from surface contexts and has not yet been analysed. Floatation of two samples of sediment from the MSA level resulted in recovery of several small fragments of unidentifiable bone but no plant remains were recovered.

The chipped siliceous mudstone artifacts from the MSA and Kintampo components are distinguishable from one another on the basis of two criteria. Kintampo lithic technology is primarily bipolar, a technique that produces shattered and broken pieces rather than the flakes and cores that are characteristic of free-hand percussion (Casey 1998, 2000). The inventory of Kintampo chipped stone includes pieces from bipolar reduction, microliths and some highly stylised projectile points (Casey 1998) (Fig. 1).

The MSA artifacts show evidence of having been produced using freehand percussion, and can be classified using categories such as "cores" and "flakes". The MSA reduction sequences have not yet been determined, but it is possible to make a few observations. The few cores that have been recovered could most easily be classified as discoidal cores or centripetal recurrent Levallois cores. There are a few examples of flakes that could be classified as Levallois, but these may also have been produced using a non-Levallois reduction sequence. A noticeable proportion of the flakes is elongated with parallel sides, but typically such flakes are not long enough to be classified as "blades". There are few formed tools from the MSA component, but those present include a basally-thinned flake, a foliate biface, a broken partial biface and a number of unifacial denticulated tools (Fig. 2). The MSA of West Africa is very poorly known, but this material appears to bear general similarities to MSA artifacts recovered from Côte d'Ivoire (Lioubine and Guede 2000), Burkina Faso and southern Niger (Vernet 1996). Foliates and basally-thinned tools are typical of the MSA from elsewhere in Africa and have not been described for the "Macrolithic Later Stone Age" (MacDonald and Allsworth-Jones 1994).

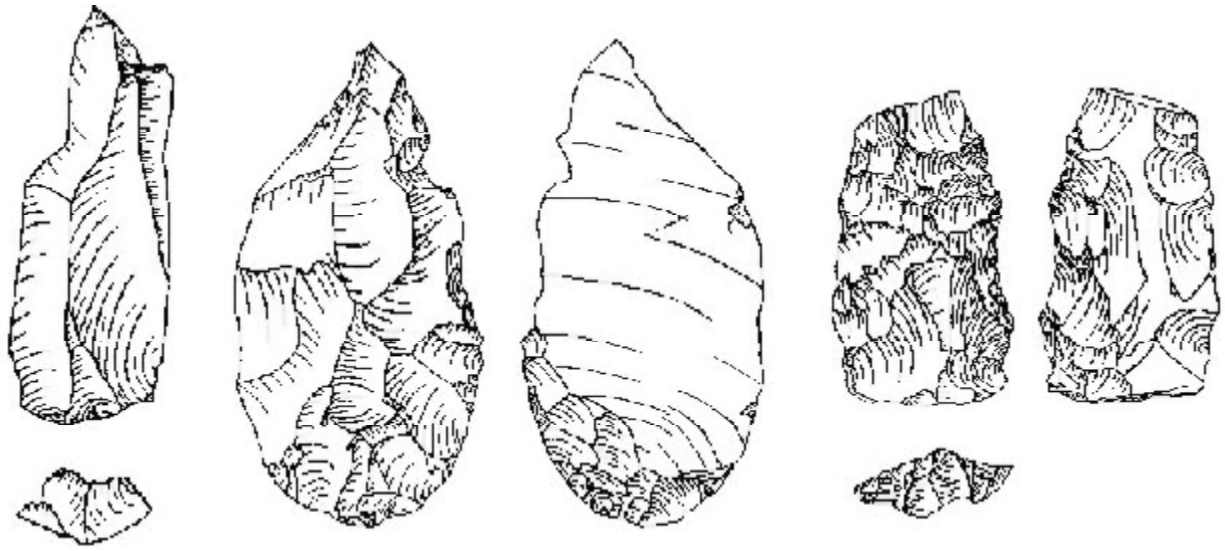


Figure 2. Typical MSA Artifacts from the Birimi Site

The condition of the artifacts is the other major criterion that used to distinguish between objects from the two components. The Kintampo pieces have sharp edges, occur in shades of grey-blue-green and reds and rarely show evidence of surface discoloration. The MSA artifacts show variation in freshness, with some pieces having sharp edges while others appear to have been smoothed by erosion. They usually occur in shades of brown and yellow, often mottled with a milky coloured patina, and broken pieces show clearly that the surface of the artifacts is discoloured compared with the interior.

Casey (2000) has analysed lithic assemblages from several other Kintampo sites in the area and found no evidence for flakes and cores such as are described for the MSA component. Although work on the

MSA at Birimi is still in its preliminary stages, it is clear that there are two separate components represented, and that artifacts from each can be easily distinguished even when they occur on the surface.

The reoccupation of Birimi during three separate periods raises the question of what advantage this location possessed. Today, it offers no obvious benefits compared with locations further up or downstream. Brief survey of the area near the Birimi site showed that there were no comparable concentrations of MSA artifacts on the opposite bank of the stream. While the area of concentrated MSA artifacts on the surface differs slightly from that of Kintampo artifacts, which again differs from the concentration of Iron Age materials, there is a large zone of overlap. The topography of the site may have been different during the Kintampo and MSA occupations because the drainage of the Birimi stream is likely to have changed over time.

This raises the possibility that one of the site selection criteria of Kintampo and Iron Age inhabitants was presence of visible artifacts. If MSA artifacts were systematically re-used for chipped stone artifacts by Kintampo people we would expect to see evidence of this in the form of recent retouch on MSA tools, ground edges on MSA tools and old surfaces on pieces produced by bipolar reduction. There is little evidence of this kind: a single artifact identified as MSA on the basis of form also has ground edges. Therefore, it seems improbable that the Kintampo inhabitants chose this location because of the presence of a potential raw material source for chipped stone. This does not exclude the possibility that the presence of artifacts was a selection criterion.

The source of siliceous mudstone warrants study because the Gambaga Escarpment region was likely used in different ways during the Kintampo and MSA occupations. There is good evidence for at least some degree of sedentism during the Kintampo. At Birimi, evidence for this lies in the presence of structural remains and cultigens (D'Andrea *et al.* 2001). By contrast, MSA peoples in Africa are assumed to have been hunter-gatherers with some degree of mobility. Preliminary examination of both the Kintampo and MSA lithic material suggests that reduction was carried out on-site, and that sizeable pieces of siliceous mudstone were transferred to the site for this purpose. Evidence for this from the MSA material comes from a high proportion of unretouched flakes, chips and chunks, the presence of cortical flakes and a low proportion of retouched tools. The Kintampo siliceous mudstone artifacts include debris from bipolar reduction, preforms and broken tools (Casey 1998:90), also indicating on-site reduction of stone.

None of the lithic raw materials that are represented at Birimi are found on-site. The closest known source of siliceous mudstone is an outcrop approximately 25 km from Birimi. This outcrop is used today as a source for gunflints, and archaeologists were directed to it in 1987 by vendors in a local market. It is a heavily brush-covered hillock that consists of tabular pieces of siliceous mudstone of different colours. Workers at the Birimi site suggested that siliceous mudstone could also be found exposed in the Gambaga Escarpment and a regional map indicated an exposure of mudstone at the foot of the scarp. For these reasons the area north of the site was surveyed. No outcrops were observed and very few artifacts were found. We did observe mudstone at the foot of the escarpment, but it was not siliceous.

In sum, the archaeological evidence suggests that use of the landscape would have been different during the Kintampo and MSA periods; during both periods people brought siliceous mudstone to Birimi for reduction; and possibly the source of this material was found at a substantial distance. Given the above,

artifacts from the Birmi site and pieces from the outcrop were analysed to determine whether the same source was used during the two periods and whether this source could have been the known outcrop.

Sampling

The archaeological material analysed included 18 artifacts identified as MSA and eight pieces identified as Kintampo. The MSA pieces included artifacts found *in situ* (three pieces) as well as surface materials (15 pieces). Eleven of the selected MSA pieces were described as patinated and variation in colour was one of the selection criteria for sampling. The MSA artifacts were subsampled. The Kintampo sample consisted of eight whole artifacts, including serrated projectile points that were analysed in their entirety.

Twenty-two sub-samples were from geological material taken from the nearest known outcrop of suitable lithic raw material to the Birimi archaeological site. The outcrop is located in the Voltaian Formation 10 km south of Nagbo, and approximately 25 km from Birimi. The siliceous mudstone varied in quality from "chert-like" to friable shale. The criteria for selection of pieces for analysis included variation in colour and degree of silicification.

Analytical Procedure

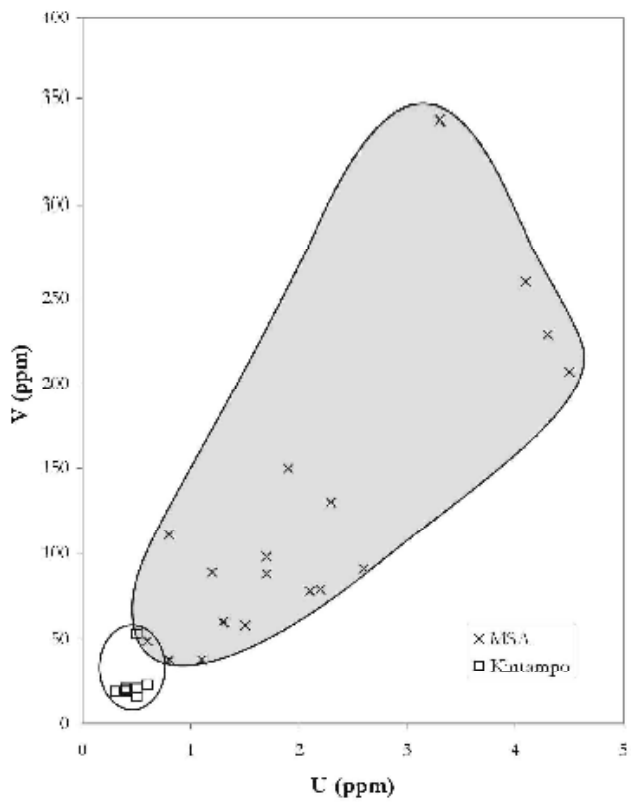


Figure 3. Scattergram of the Concentrations of Vanadium vs. Uranium for MSA and Kintampo Artifacts

The samples were subject to Instrumental Neutron Activation Analysis (INAA) at the SLOWPOKE Reactor Facility of the University of Toronto. Individual samples were stored in 1.2 mL polyethylene vials and were analysed essentially as described by Hancock (1978). Samples of 10-20 mg were first irradiated serially for five minutes at a neutron flux of 5.0 X 1011n.cm-2.s-1 and assayed for five minutes after a delay time of approximately eighteen minutes to allow the aluminium to decay to measurable levels using germanium detector-based gamma ray spectrometers. Elemental concentrations were calculated using the comparator method (Hancock 1978). Larger samples were irradiated at suitably lower neutron fluxes so that a relatively consistent total amount of radioactivity was produced in each sample. Special care was taken with eight rare Kintampo artifacts that were irradiated in their entirety so as not to cause any sampling damage to them.

Results and Discussion

INAA results for the analysed objects are presented in Table 1 (MSA), Table 2 (Kintampo)

and Table 3 (Outcrop samples). The elements that were identified and quantified in the SLOWPOKE Reactor are aluminium, calcium, chlorine, dysprosium, manganese, silicon, titanium, uranium, vanadium, barium, potassium and sodium.

Comparison of the chemistry of the MSA and Kintampo artifacts shows that there is a significant difference in the mean concentrations of a number of elements (Cl, Mn, Ti, U, V, Ba, and K). The concentrations were compared using a difference of means test. Although significant differences in the elemental concentrations of MSA and Kintampo artifacts do occur, scattergrams show three things:

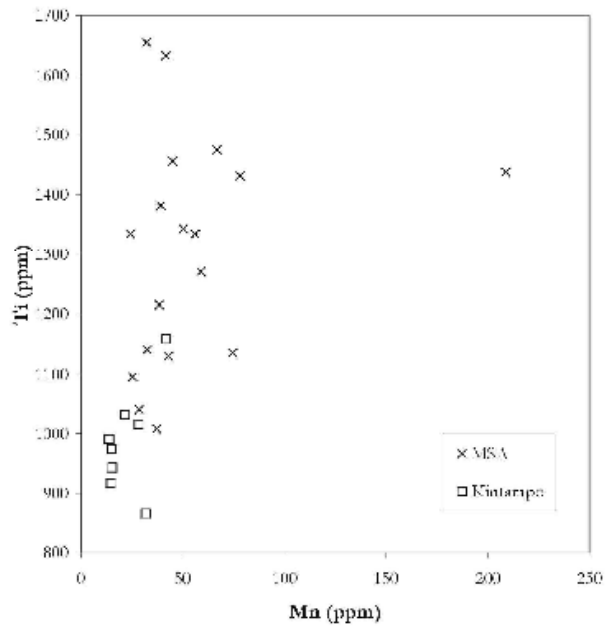


Figure 4. Scattergram of the Concentrations of Titanium vs. Manganese for MSA and Kintampo Artifacts

1. Even in cases where the concentrations of two elements appear to be quite different, there is never a complete separation between the two groups (e.g., Fig. 3);
2. The range of variation in the chemistry of the MSA artifacts is much greater than that of the Kintampo artifacts (Fig. 3 and Fig. 4); and
3. The relationship between concentrations of most elements is approximately linear (e.g., Fig. 4).

Table 1. Elemental concentrations for Middle Stone Age (MSA) artifacts from the Birimi site. The mean concentration of elements listed in bold is significantly different from the mean concentration of analysed Kintampo artifacts.

Al) (%)	Ca (%)	Cl (ppm)	Dy (ppm)	**Mn** (ppm)	Si (%)	Ti (ppm)	U (ppm)	V (ppm)	Ba (ppm)	K (%)	Na (%)
3.3	0.025	**62**	14	**43**	44	**1130**	**1.1**	**38**	**450**	**0.6**	0.033
3.5	0.061	**55**	2	**41.6**	40	**1633**	**2.1**	**78**	**633**	**0.72**	0.037
3.6	0.061	**80**	1.4	**32.2**	52	**1655**	**0.8**	**111**	**176**	**0.59**	0.041
3.1	0.069	**48**	2.7	**74.5**	27	**1136**	**4.5**	**207**	**258**	**0.63**	0.031
4.1	0.027	**31**	3	**209**	26	**1438**	**4.3**	**229**	**276**	**0.65**	0.035
3.1	0.053	**91**	2.1	**56.1**	36	**1335**	**4.1**	**260**	**207**	**0.64**	0.036
3.4	0.032	**93**	2.8	**78.3**	36	**1432**	**2.3**	**130**	**298**	**0.81**	0.047
3.4	0.069	**100**	1.2	**39.3**	40	**1382**	**1.7**	**88**	**349**	**0.55**	0.048
2.4	0.053	**66**	2.1	**50.4**	38	**1343**	**3.3**	**340**	**534**	**0.5**	0.053
3.2	0.024	**59**	1.8	**66.8**	40	**1476**	**2.2**	**79**	**511**	**0.57**	0.047
3.7	0.064	**89**	2.4	**45**	39	**1456**	**1.9**	**150**	**732**	**0.99**	0.05
2.7	0.062	**64**	2.3	**58.9**	42	**1271**	**2.6**	**91**	**766**	**0.54**	0.056
1.8	0.030	**145**	1.5	**25.3**	42	**1096**	**0.8**	**38**	**543**	**0.5**	0.058
3.3	0.026	**133**	1.9	**24.2**	39	**1335**	**0.6**	**49**	**539**	**0.65**	0.049
2.9	0.097	**55**	2.7	**38.5**	39	**1215**	**1.2**	**89**	**696**	**0.55**	0.032
2.9	0.029	**68**	2.4	**37.2**	35	**1008**	**1.7**	**98**	**1024**	**0.69**	0.056
2.8	0.027	**72**	2.6	**28.5**	38	**1040**	**1.3**	**60**	**965**	**58**	0.05
2.9	0.029	**131**	1.5	**32.6**	43	**1141**	**1.5**	**58**	**453**	**0.49**	0.049

Table 2. Elemental concentrations of Kintampo artifacts from the Birimi site. The mean concentrations of elements listed in bold are significantly different than the mean concentrations of MSA artifacts.

Al) (%)	Ca (%)	Cl (ppm)	Dy (ppm)	**Mn** (ppm)	Si (%)	Ti (ppm)	U (ppm)	V (ppm)	Ba (ppm)	K (ppm)	Na (%)	(%)
2.4	0.058	**46**	1.7	**28.2**	44	**1016**	**0.4**	**20**	**1707**	**0.56**	0.085	
2.7	0.034	**61**	6.2	**15.3**	38	**943**	**0.4**	**21**	**488**	**0.58**	0.067	
2.5	0.053	**42**	1.3	**13.8**	36	**991**	**0.4**	**19**	**1027**	**0.54**	0.058	
2.4	0.055	**63**	1.6	**21.6**	42	**1031**	**0.3**	**19**	**1772**	**0.53**	0.067	
2.4	0.019	**55**	2.2	**14.6**	38	**917**	**0.5**	**16**	**2815**	**0.512**	0.086	
2.5	0.017	**62**	2	**41.8**	44	**1158**	**0.6**	**23**	**719**	**0.6**	0.079	
2	0.050	**86**	0.8	**31.6**	38	**867**	**0.5**	**53**	**607**	**0.58**	0.067	
2.9	0.055	**46**	2.4	**15**	40	**974**	**0.5**	**21**	**796**	**0.64**	0.042	

Table 3. Elemental concentrations of siliceous mudstone samples from the outcrop location south of Nagbo.

Al) (%)	Ca (%)	Cl (ppm)	Dy (ppm)	**Mn** (ppm)	Si (%)	Ti (ppm)	U (ppm)	V (ppm)	Ba (ppm)	K (ppm)	Na (%)	(%)
3.3	0.032	72	1.8	14.6	42	1497	0.8	28	69	0.75	0.05	
1.9	0.049	125	7	31	43	940	0.5	58	245	0.42	0.037	
2.2	0.041	137	1.5	33.8	54	1485	3.2	46	515	0.61	0.048	
2.7	0.032	140	2.6	20.6	46	1509	0.8	24	329	0.6	0.049	
1.7	0.030	99	1	35	40	1082	2.2	52	35	0.32	0.047	
2.6	0.100	85	1.2	52.8	36	1239	0.7	37	67	0.9	0.088	
3.2	0.070	78	2.5	17.5	45	1461	0.5	27	7900	0.65	0.107	
1.5	0.166	83	2.8	187	32	374	0.4	54	61	0.4	0.152	
3.2	0.060	54	0.9	715	36	2276	2.1	67	520	0.86	0.037	
2.3	0.162	90	2.1	1305	42	2221	2	35	1180	0.31	0.039	
2.8	0.188	103	1.2	39.3	40	1304	0.5	35	1345	0.75	0.039	
3.1	0.185	95	1.4	51.8	28	1300	0.3	39	42	0.89	0.044	
3.2	0.027	51	1.6	13.9	28	1247	0.3	45	46	0.77	0.043	
3.1	0.036	59	2.4	14.2	42	1197	0.7	41	6500	0.68	0.039	
2.2	0.074	164	0.7	36.1	41	978	1.4	84	160	0.48	0.041	
1.4	0.022	85	1.6	8.48	40	536	0.7	50	6250	0.22	0.028	
2.8	3.410	75	1.7	508	30	1473	0.9	62	125	0.65	0.265	
3.0	0.124	116	2.5	1422	42	2204	5.9	55	18950	0.38	0.04	
2.8	0.790	43	1.6	277	40	1278	0.5	35	377	0.86	0.255	
5.2	0.060	90	0.6	79.8	45	1547	0.5	53	13850	0.91	0.078	
2.6	0.075	66	1.5	97.2	37	1633	1.1	59	70	1.06	0.047	
2.9	0.059	56	1.5	42.4	38	1119	0.3	42	414	0.75	0.039	

All of these observations could be attributed to the weathering process, which would result in the enrichment of non-erodible components in the artifacts. Figures 3 and 4 show that there is some evidence for this for the MSA artifacts. Despite this, the higher concentrations of specific elements, such as aluminium, in more highly weathered artifacts is not consistent and certainly would not be predictable (Fig. 5). Note that

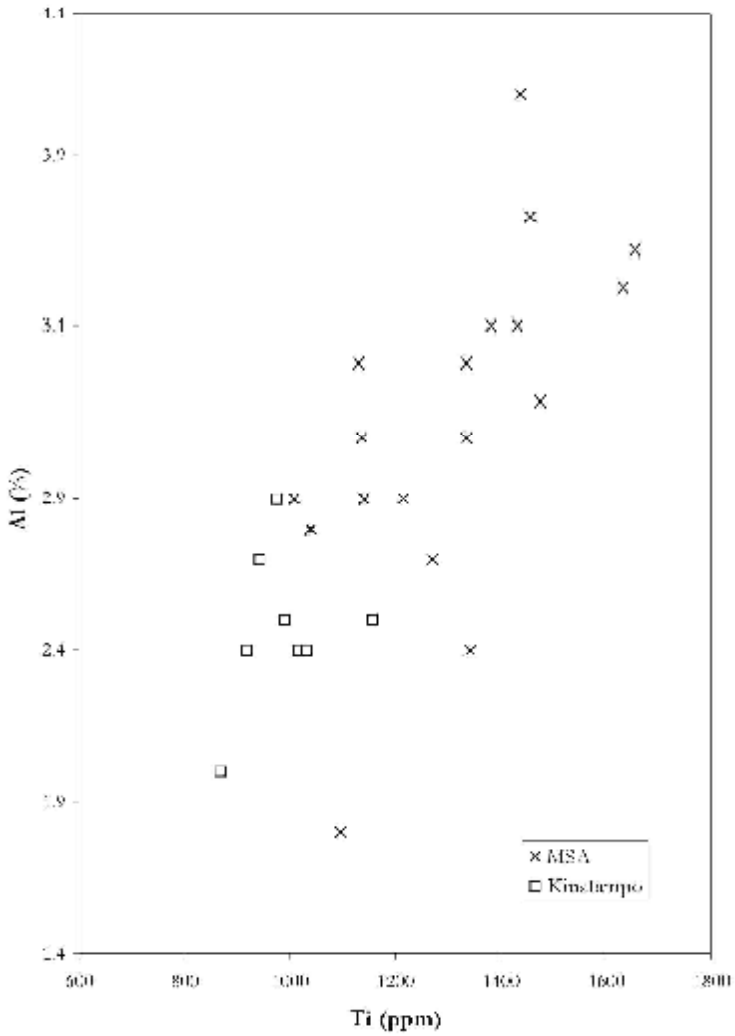


Figure 5. Scattergram of the Concentrations of Titanium vs. Aluminium for MSA and Kintampo Artifacts

some of the MSA specimens have concentrations of Al and Ti that are similar to concentrations for Kintampo artifacts, and one specimen has concentrations that are below those observed for Kintampo artifacts.

These data indicate that there is no evidence that a different source of raw material was used during MSA and Kintampo times. That the differences are consistent with weathering supports the idea that leaching and replacement occurred for several tens of thousands of years for the MSA material and only a few thousand years for the Kintampo materials. The chemical differences observed cannot be attributed entirely to differences in patination. Alternate explanations for the differences between the MSA and the Kintampo artifacts lie with cultural selection processes. It is possible that during the MSA much larger nodules were selected for reduction and it was not possible to find pieces that were as highly silicified as those used by the Kintampo people. Finally, it is possible that the difference in the chemistry of the two groups of artifacts is somehow related to cultural preferences for particular colours of mudstone. However, this idea was discarded after further examination of the material from Birimi because colour differences appear to be related to weathering.

Examination of the elemental concentrations of samples from the outcrop compared with the artifacts shows that the variability in the chemistry of outcrop mudstone is far in excess of the chemical variability of the Birimi artifacts. For example, Figure 6 shows the concentrations of Al and Ti in all analysed material. All of the archaeological specimens fall well within the range of variation for the outcrop samples. This indicates that, based on the known chemistry, there is nothing to suggest that the raw material was not obtained from this location. It is important to point out that this chemical comparison is a “negative test”. Although it may be possible to show that an artifact did not derive from a particular outcrop, it is usually not possible, in this type of study, to state unequivocally that the artifact did come from an outcrop with a similar chemical makeup.

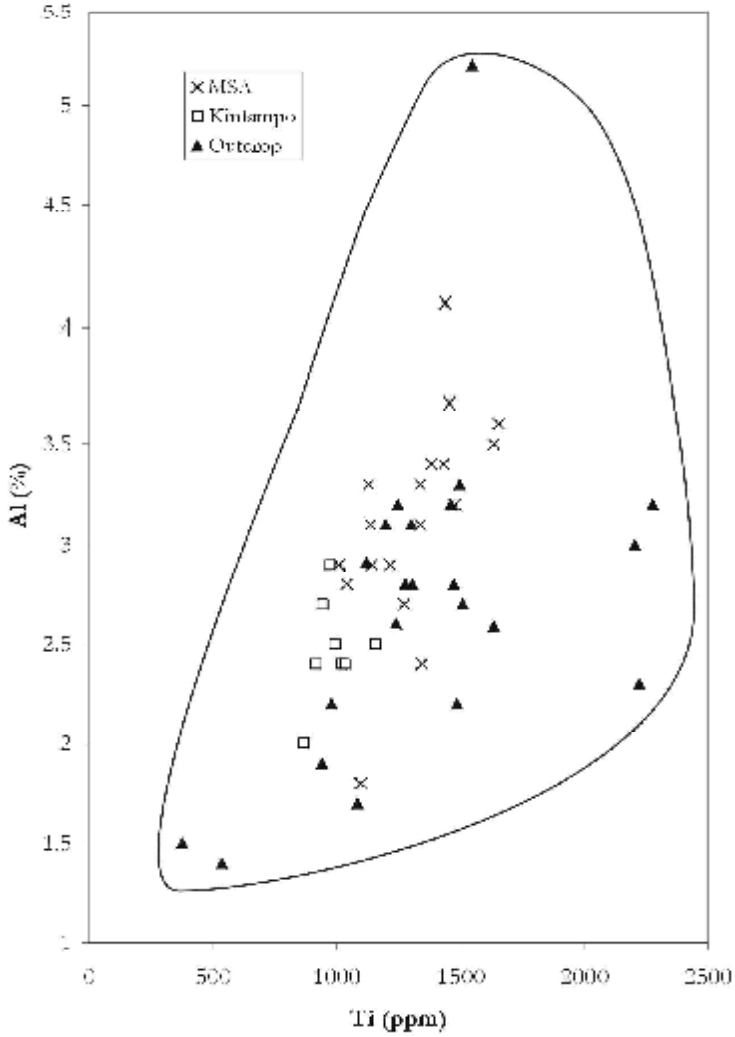


Figure 6. Scattergram of the Concentrations of Titanium vs. Aluminium for All Analysed Samples

Disclaimers noted, it can be seen that the Kintampo artifacts cluster on the scattergrams suggest that their makers were selecting a very particular mudstone that was highly siliceous and of a chemically consistent material.

Conclusions

The conclusions of the chemical study suggest to us that all of the siliceous mudstone at Birimi could have been obtained from the known outcrop. It is equally possible that the mudstone was obtained from a different source or sources in the same formation. There are chemical differences between the two groups of artifacts, but none that suggest use of different geological sources. At this time, it is not possible to determine to what extent the differences are attributable to weathering, to different selection criteria by the two groups or to a combination of the two.

The great chemical variability in the geological specimens as compared with the archaeological ones indicates that, if the known outcrop was used as a raw material source, then people clearly selected particular types of mudstone.

Future research on the sources of siliceous mudstone is warranted, as questions about human use of the landscape remain open. In particular, it is important to establish whether other outcrop locations are found closer to Birimi. If such outcrops exist, it would be useful to test whether the chemistry of the siliceous mudstone from them is the same as that from the known outcrop. If it can be established that outcrops do not exist, then the question of why people transported sizeable pieces of raw material over 25 km for reduction needs to be addressed.

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