Composition and Provenance of Greenstone Artifacts from Moundville

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Introduction

At the Moundville site in west-central Alabama (A.D. 1000-1650), greenstone was commonly used to make celts (Figures 1, 2). Our objectives are to describe the mineralogy and chemical composition of greenstone artifacts found at Moundville, and to determine as closely as possible their geological sources.

Greenstone is a very general term used in geology to describe a great variety of rock types usually formed from the low-grade metamorphism of mafic and ultramafic igneous rocks or their sedimentary equivalents. These rocks typically are green in color, are easily shaped by pecking and grinding, and yield serviceable tools that hold their shape and polish.

It has long been believed that the Moundville greenstones originated in the Hillabee Metavolcanic Complex of eastern Alabama, but until recently this assumption had never been rigorously tested (Gall 1995; Gall and Steponaitis 2001) .

In order to test this assumption and to determine the sources more precisely, 62 greenstone samples were collected from the Hillabee formation and a subset of these was subjected to both mineralogical and chemical analyses. Similar studies were done on a sample of 28 greenstone celts from Moundville, so their compositions could be compared.

Figure 1. Typical greenstone celts from Moundville, all showing signs of breakage and wear.

Figure 2. Hafted greenstone celt found in the Black Warrior River near Moundville. The wooden handle is approximately 70 cm long.

Hillabee Metavolcanic Complex

The Hillabee Metavolcanic Complex is a long, narrow belt of metamorphosed basalt flows and associated rocks that emerges from beneath the Coastal Plain sediments in Chilton County, Alabama, trends in a northeasterly direction for approximately 170 km, and ends abruptly in Cleburne County, Alabama (Figure 3). For analytical purposes, the formation can be divided into three geographical segments: Northern, Central, and Southern (Figure 4).

The Hillabee formation consists of three major rock types: (*a*) mafic phyllite, (*b*) massive greenstone, and (*c*) a hornblende-bearing siliceous phyllite/gneiss (Tull et al. 1978). Of these three, only the massive greenstones are suitable for making celts, and these tend to be relatively uncommon within the formation as a whole. The phyllites are easily weathered and tend to form eroded valleys. The massive greenstones, on the other hand, are much more resistant to weathering and therefore tend to form low hills and ridges, and small waterfalls and rapids in stream channels. Thus, the prime sources of celt-grade material are not common but relatively easy to locate in the field.

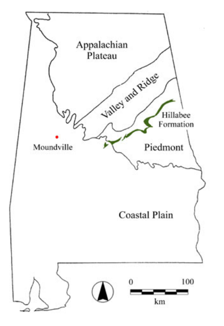

Figure 3. Map of Alabama showing the locations of Moundville and the Hillabee Metavolcanic Complex.

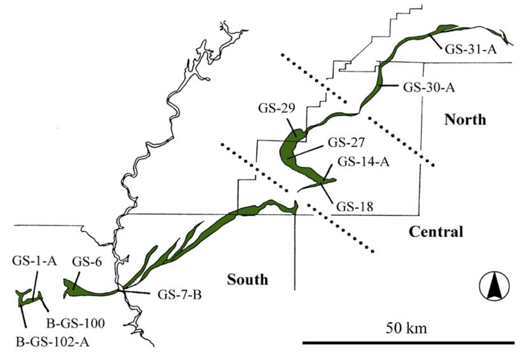

Figure 4. Map of the Hillabee Metavolcanic Complex, showing the Northern, Central, and Southern areas, as well as the locations of greenstone samples that were chemically analyzed.

Mineralogy

Mineralogical studies were carried out on 27 Hillabee rock samples and 28 Moundville celts, using both petrography and x-ray diffraction.

The massive Hillabee greenstones occur in five textures: metadiabasic, granoblastic,crudely foliated, mylonitic, and phylitic (Figure 5, left). Yet even though Hillabee greenstones differ in color and texture, they do not differ significantly in mineralogy. All composed of roughly similar amounts of actinolite, epidote, and albite. These rocks can be classified as very-fine- to medium-grained, massive to crudely foliated, actinolite-epidote-albite metabasites.

Moundville celts are mineralogically identical to the Hillabee greenstones. Only three textures are represented among the Moundville artifacts – metadiabasic, granoblastic, and crudely foliated – which tend to be the best ones for making celts (Figure 5, right).

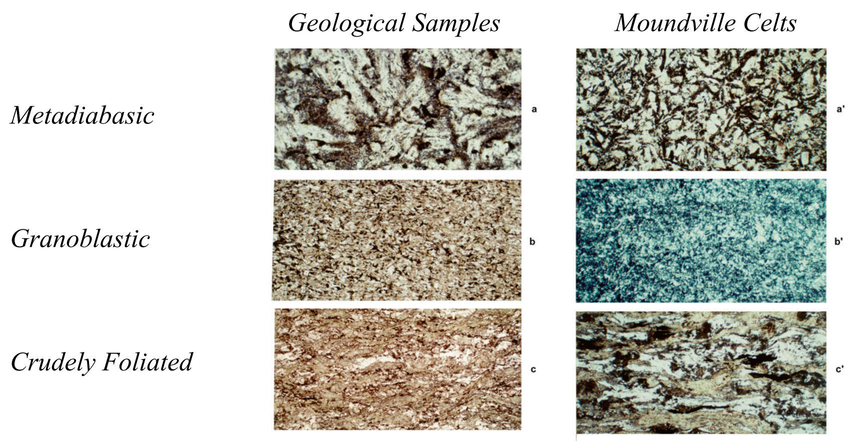

Figure 5. Thin sections of geological samples (*left*) and Moundville celts (*right*) showing characteristic textures of Hillabee greenstones: (*a-a'*), metadiabasic; (*b-b'*) granoblastic; and (*c-c'*) crudely foliated. The long dimension of photograph (*a*) corresponds to 1 mm on the thin section; the long dimensions of all the rest correspond to 5 mm. All photographs were taken in plane-polarized light, except for (*b'*) which was taken in cross-polarized light.

Table 1. Elemental Composition of Moundville Celts in Comparison to Hillabee Greenstones.

Category: Element	Moundville Celts Mean	Moundville Celts Range	Overall Hillabee Mean	Overall Hillabee Range
Major:				
Na_2O (%)	2.25	1.35-3.78	2.65	0.38-4.30
CaO (%)	11.13	7.97-12.59	12.03	8.16-18.20
Fe_2O_3 (%)	10.85	8.01-14.16	11.62	7.27-14.70
Trace (Misc.):				
Co (ppm)	47.8	24.0-59.0	54.4	36.0-70.0
Sc (ppm)	43.2	30.7-48.4	43	31.9-49.8
Cr (ppm)	278.9	20.0-350.0	225.5	61.0-490.0
Hf (ppm)	1.6	1.0-3.0	2.4	1.8-2.9
Zn (ppm)	103.9	40.0-240.0	76.3	33.0-110.0
Rare Earths:				
La (ppm)	4.1	3.0-8.0	3.9	1.3-6.0
Ce (ppm)	10.9	8.0-21.0	11	5.0-16.0
Sm (ppm)	2.2	1.7-3.8	2.53	1.55-3.32
Eu (ppm)	0.9	0.6-1.8	1.13	0.68-1.86
Tb (ppm)	0.6	0.5-0.8	0.6	0.3-0.9
Yb (ppm)	2.2	1.5-3.7	2.35	1.28-2.95
Lu (ppm)	0.33	0.20-0.56	0.36	0.21-0.48

Chemistry

Eleven samples of Hillabee greenstone and 28 Moundville celts were selected for chemical analysis by means of instrumental neutron activation. Of the 33 elements that the analytical protocol was capable of determining, 15 were typically found in the samples.

The average chemical compositions of Hillabee greenstones match those of low-potassium, low-aluminum tholeiitic basalts. Interestingly, the rock samples show a strong inverse relationship between sodium and calcium, which correlates with geography. As one moves from north to south along the Hillabee formation's strike, the amount of sodium decreases and the amount of calcium increases (Figure 6).

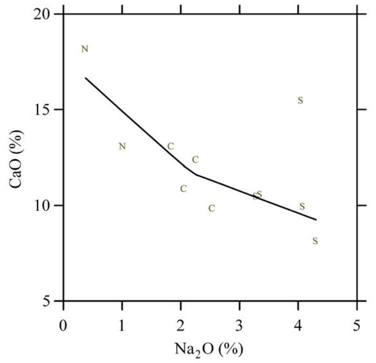

Figure 6. Scatterplot of calcium (CaO) versus sodium (Na_2O) in geological specimens of Hillabee greenstone. Resistant line fitted by LOWESS smoothing, $f = 1$. Key: N, Northern Hillabee; C, Central Hillabee; S, Southern Hillabee.

The Moundville celts have the same composition as the Hillabee rock samples: the same elements are present in very similar concentrations (Table 1). And just as in the Hillabee samples, sodium varies inversely with calcium. This finding allows us to locate more precisely the sources of the rock used to make these artifacts.

In terms of sodium concentrations, most of the Moundville celts compare favorably with the geological specimens from the Central Hillabee area (Figure 7). The one exception has much more sodium than the rest, a value consistent with the Southern Hillabee area.

Calcium concentrations show a generally similar pattern (Figure 8). The overall distribution of values for Moundville celts is most similar to that for the Central Hillabee samples, although there are a few outliers that seem to fall within the range of the Southern Hillabee samples.

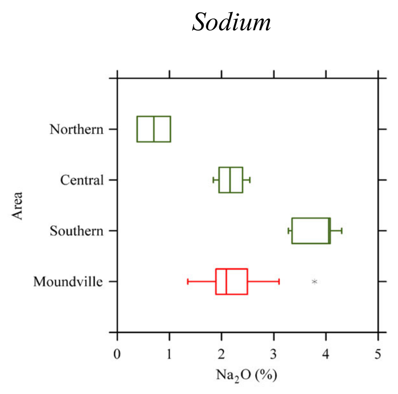

Figure 7. Boxplots of sodium (Na_2O) concentrations in geological specimens from the three Hillabee areas and in archaeological specimens from Moundville.

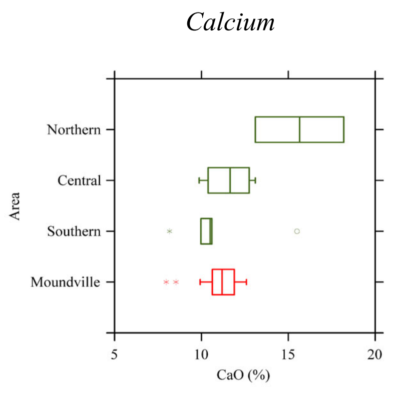

Figure 8. Boxplots of calcium (CaO) concentrations in geological specimens from the three Hillabee areas and in archaeological specimens from Moundville.

Conclusions

- The main sources of Moundville greenstone are located in the Central portion of the Hillabee Metavolcanic Complex. A small amount of Moundville greenstone came from the Southern Hillabee area, and no greenstones at all were used from the Northern Hillabee.
- Within the Central Hillabee area, most of the celt-grade greenstone outcrops occur along the Hatchet Upper Creek valley in Clay County, about 150 km east-northeast of Moundville (Figure 9). In colonial times, an Creek town named *Pochushâchi* was located in this valley; Read (1984:35) suggested that the name was derived from either *pochuswuchi hâchi*, "hatchet creek," or *pochuswa hâchi*, "ax creek." Evidently, Hatchet Creek owes its name to the Indians who for centuries exploited its greenstone outcrops for celt stone.
- The best sources of celt-grade material in the Southern Hillabee area are located along Gale Creek in Chilton County, only 85 km east-southeast of Moundville (Figure 9). Here, outcrops of greenstone form rapids within the creek itself, and greenstone boulders occur throughout the alluvial deposits (Figure 10).

In summary, the available evidence suggests that greenstone was obtained by Moundville's inhabitants directly, by means of procurement expeditions to sources located along Gale Creek in Chilton County and Hatchet Creek in Clay County. These sources are 85 km and 150 km from Moundville, respectively. The toughness of greenstone makes it very difficult to mine (in the sense of breaking pieces directly from outcrops), especially without metal tools. Thus, the ancient Indians probably collected weathered cobbles of the appropriate size and shape, which can be readily found in stream beds near the outcrops. The initial stages of reduction probably took place near the sources, and the celts eventually were brought to Moundville in a finished or partly finished state (Wilson 2001). Exactly where the intermediate and late stages of production occurred is still not known.

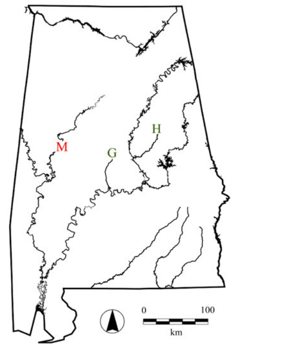

Figure 9. Map of Alabama showing the locations of the ax-grade Hillabee greenstone outcrops at Gale Creek (G) and Hatchet Creek (H) in relation to Moundville (M).

Figure 10. Gale Creek alluvium containing greenstone cobbles and boulders, Chilton County, Alabama. The hammer in the center of the photograph is 27 cm long.

Acknowledgments

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