A STUDY OF COMPOSITIONAL VARIABILITY IN METAVOLCANIC STONE FROM THE CAROLINA SLATE BELT AND THE POTENTIAL TO PROVIDE GEOLOGIC PROVENIENCE FOR STONE ARTIFACTS FOUND AT FORT BRAGG, NORTH CAROLINA:

PHASE II
RESEARCH DESIGN

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INTRODUCTION

The scales of analysis relevant to the archaeology of prehistoric hunter-gatherers range from particular aspects of stone tool function to regional settlement organization. As we accumulate information on thousands of archaeological sites or isolates through cultural resource management of Fort Bragg, an Army installation of over 160,000 acres, finding an appropriate scale of analysis for this data is critical. Through the lithic provenience study outlined here, we have begun to develop one relevant scale of analysis that may effectively involve Fort Bragg and multiple regions beyond the Sandhills. The scale of analysis is the cultural landscape of those prehistoric hunters and gatherers who included the Sandhills in their subsistence economies, mobility patterns, and social territories. The unit of analysis is stone, both from prehistoric quarries and associated outcrops, and in the form of artifacts recovered in the Sandhills.

Insofar as we are trying to establish techniques to determine the geologic provenience of prehistoric stone artifacts, the focus of this research is methodological. It is driven, however, by particular research questions about the prehistoric conveyance of stone and more general research questions about prehistoric culture. Assuming direct procurement of stone by hunter-gatherers who used or moved through the Sandhills, we are mapping through lithic provenience what Binford calls the "mobility scale" of hunter-gatherer settlement systems (1979:261). Ultimately, by recognizing patterns of movement across the landscape, we may detect evidence of the territories formed by hunter-gatherers and those resources to which they were particularly attached. Furthermore, modeling of stone procurement and conveyance should allow for refinement of existing settlement models, if not construction of new ones.

BACKGROUND

Project Team

The research outlined here is the second and final phase of a project initiated by Fort Bragg and contracted through the U.S. Army's Construction Engineering Research Laboratory (CERL). As multiple organizations and professional consultants have been called upon to develop this project, a project team has been assembled. The following individuals are key players on this team: Mr. Tad Britt (CERL), Mr. Jeff Irwin (Fort Bragg), Mr. Chris Moore (Fort Bragg and TRC), Dr. Brent Miller (UNC, Chapel Hill), Dr. Vin Steponaitis (UNC, Chapel Hill), Dr. Skip Stoddard (N.C. State), and Mr. Paul Webb (TRC).

Archaeology of Fort Bragg

Our perspective on prehistoric landscapes originates from a seemingly marginal region. Located in the interior Coastal Plain of North Carolina, the Sandhills have been referred to historically as the "Pine Barrens", "Pine Plains", even the "Sahara of the Carolinas". The Sandhills mark an ancient coastal dune environment that is characterized today by dissected sandy hills, longleaf pine/wiregrass forest, and acidic, arid sands along ridges and side slopes. Nutrient-poor soils and a typically non-mast pine forest make the region generally less productive in terms of plant and faunal resources than neighboring zones such as the Piedmont and Coastal Plain. Nonetheless, the area was persistently used throughout prehistory, as indicated by the presence thus far of approximately 3,200 prehistoric sites and occurrences on Fort Bragg.

The relative frequency of sites or occurrences increases or remains stable throughout the Archaic period and into the Middle to Late Woodland. These sites and isolates generally represent ephemeral occupations or limited activities distributed throughout this upland Coastal

Plain setting. Archaic and Woodland components alike are small, characterized by relatively low-density and low-diversity deposits. The ephemeral nature of most sites and the apparent small size of groups using the area suggest these hunter/gatherers were highly mobile and integrated into a larger foraging pattern. Indeed we know from ethnographic and archaeological studies that the foraging ranges of hunter-gatherers can cover hundreds or thousands of square kilometers (Kelly 1995; Jones et al. 2003).

It has been posited elsewhere (Moore and Irwin 2002) that key resource draws effectively bracketed the Sandhills. To the west, the Piedmont offered two critical resources, a rich mast-producing deciduous forest and abundant metavolcanic stone from the Carolina Slate Belt. To the east the Coastal Plain offered Carolina Bays, marine resources on the coast, and anadromous fish runs along streams and rivers in the spring. Situated between these resource draws, the Sandhills certainly figured only as one spatial component of larger territories.

Stone raw material use at Fort Bragg corroborates this scenario. In one study, a majority of diagnostic hafted bifaces, i.e., points, from the Archaic period derive from non-local materials, most of which are considered to be metavolcanic stone from the Slate Belt. Use of metavolcanic stone was particularly common in the Archaic, constituting from 59 to 79 percent of projectile points. This pattern is nearly reversed in the Middle-to-Late Woodland when increased use of quartz is associated with the shift to triangular arrow tips. Still, metavolcanic stone occurs in more than a third of all such points (Culpepper et al. 2000: 36-41).

As we become more familiar with the archaeological record of the Sandhills and Cape Fear region, including local amateur collections, it appears the tethering effect of the stone-rich Slate Belt was not as great as perhaps once thought. Prehistoric groups were able to extend their foraging range from the quarry region by provisioning themselves with raw material through curation, caching, and embedded procurement. Early Archaic tools, in particular, appear to be highly curated. Caching behavior appears in the Middle Archaic, with several flake blank caches occurring in the Sandhills and upper Cape Fear area. In addition, locally available quartz was used to supplement the stone toolkit throughout prehistory. These measures allowed groups who preferred metavolcanic stone the flexibility of ranging far from the Slate Belt and well into the Coastal Plain. Consequently, these practices allow us the opportunity to detect patterns of prehistoric movement by connecting the artifact to its often-distant origin.

PHASE I

In the first phase of this study, 50 rock samples from 20 quarry sites were subjected to a series of independent analyses: Petrography, Samarium-Neodymium Isotope, and Instrumental Neutron Activation Analysis (INAA). The combination of petrographic and geochemical techniques was designed as an exploratory study of the variability present in these rocks and the potential for distinct signatures of individual quarries or quarry groups. Beyond individual stone specimens, the analytical unit in Phase I was the quarry group. Although the term "group" was used, most discrete analytical units were actually individual quarries. The principal components analysis conducted by Speakman and Glascock (2002) and the comparison of Samarium-Neodymium isotope ratios by Miller (2002) both relied upon 8 "groups": Cape Fear, Chatham 1, Chatham 2, Chatham 3, Durham, Person, Uwharries 1, and Uwharries 2.

Among the quarry sites or groups sampled in Phase I, the Uwharries 1 group is, by far, the best known, representing the heart of the Uwharrie National Forest in the southern piedmont and quarry sites such as Morrow Mountain, Sugarloaf Mountain and Wolfden Mountain. This area, together with the Uwharries 2 (Asheboro) area, was studied by Daniel and Butler (1996),

who documented numerous quarries. The other quarry groups, particularly Chatham, Person, Durham, and Cape Fear, are much less well known, but not necessarily less significant in modeling prehistoric cultural landscapes. Uwharries 2, Chatham, Person and Durham County quarries represent the central and northern Slate Belt. The Cape Fear samples actually derive not from a true quarry but from cobbles found on or near an archaeological site on an ancient terrace along the Cape Fear River near Fayetteville. Recent work by Ken Robinson in this area led to the discovery of these local sources and examination of collectors' materials revealed use of the same or similar raw material occurring as river cobbles near the Cape Fear River.

The Phase 1 petrographic analysis reveals a fairly complex picture in terms of the compositional variation of quarry material. Among the 50 rock samples, Stoddard has identified dacite flows and tuffs, crystal-lithic tuffs, rhyodacite, tuffaceous sandstone, metamudstone, basalt, and tuff breccia. At a general level, there is some distributional patterning of rock types. For example, the Uwharries 1 and 2 quarries are predominantly comprised of metadacite, tuffs, and felsite, or fine-grained volcanics. Plagioclase and quartz porphyritic material occurs only in the Uwharries 1 and 2 groups. Metasedimentary rocks, either metamudstone or siltstone, seem to be restricted to the Chatham and Person Counties area. The only Coastal Plain samples, those from the Cape Fear River basin near Fayetteville, are variable but include unique rock types such as basalt, metasandstone, and greenstone.

While the differences in stone and spatial patterning appear to be somewhat promising, the general overlap in physical similarity of stone and the moderate to extreme weathering that occurs on artifacts complicates use of macroscopic properties for distinguishing rock types. As with Daniel and Butler's work, in Stoddard's analysis thus far, characterization of stone based on phenocrysts continues to be important. However, the most distinctive properties are those constituent minerals in the groundmass that are identified *microscopically*, e.g., epidote, biotite, calcite, chlorite (Stoddard, personal communication), and not the more conspicuous plagioclase and quartz phenocrysts already recorded regularly in Fort Bragg lithic artifacts.

The Neodymium isotope and trace element (INAA) analyses, on the other hand, have shown considerable potential for discriminating quarries or quarry groups. Analysis of Neodymium isotopes by Miller produced perhaps the most precise "fingerprint" or signature. Distinct Neodymium values were produced for a Chatham County quarry (CH729), the Uwharries 1 group, and the Cape Fear group samples. Some quarries within the Uwharries 1 group, notably Horse Trough, may be further discriminated.

Neutron Activation analysis produced values for 32 or 33 elements for most samples, 29 of which were subjected to Principal Components Analysis by Speakman and Glascock (2002). Their statistical analysis revealed 5 clear compositional groups or quarries and 3 possible groups. Of these 8 groups, Uwharries I is the most well-defined with all other samples having "less than 1 % probability of membership in the Uwharries I group" (2002:5). Other groups show promise but require additional sampling to increase their statistical validity. Speakman and Glascock recommend a minimum sample size of six specimens per quarry/quarry group to apply principal components analysis.

Results of this initial phase of work, though preliminary, suggest the possibility to distinguish quarries/quarry groups based on one or a combination of the techniques employed. In particular, Sm-Nd ratios from several quarry groups appear distinct enough to potentially provide a comparative measure for artifact sourcing to the quarry or quarry group level. Statistical analysis of trace element data also offers a viable tool for discrimination. Petrography, though

less conducive to "fingerprinting" quarries, is critical to understanding regional and local variation in rock types.

PHASE II

Research Problems

Phase 1 of this project initiated the study of chemical and mineralogical variability in stone from particular quarries/quarry groups in the Carolina Slate Belt. This second phase of the project will advance the study with two major objectives. First, through a new sampling strategy informed by the results of Phase I and through the addition of analytical techniques not employed in the first phase, the characterization of prehistoric quarries will be continued. The overall sample of quarries will be expanded and the characterization of stone and our capacity to discriminate sources refined. Secondly, by analyzing artifacts from Fort Bragg, this second phase will allow the first application of the methods established in Phases I and II to an archaeological research problem, i.e., the prehistoric cultural landscape that included the Sandhills. Such analysis will add insight into how we can compare the compositional variability of artifacts to quarry sites or groups and facilitate an examination of the practical application of the methods being developed in this project. With these general objectives as guiding parameters, the following research problems serve to direct this phase of the study:

- Characterize chemical and mineralogical composition, and Nd-Sm isotope ratios of quarry samples and analyze the potential to discriminate sites or groups based on this data.
- Using the same techniques applied to quarry samples, initiate compositional analysis of lithic artifacts from Fort Bragg to facilitate comparative analysis with the quarry information. Address the capacity to provenience artifacts with the methods and data developed on quarries.

A significant component of this research exists in the reporting process. Beyond the descriptive results of independent consultant reports, some analysis and synthesis of results should be accomplished to produce a more interdisciplinary rather than multidisciplinary study. Interpreting the implications of this research for modeling prehistoric cultural landscapes at Fort Bragg and other regions is key. Assessing the importance of landscape and broad-scale settlement modeling for the management of archaeological sites on Fort Bragg is critical as well. Finally, a thorough analysis of the methodology developed in this project is warranted, with particular attention towards its future application in archaeology. Included in this assessment should be recommendations on the practical application of the techniques utilized in this study in terms of sampling, analysis, and interpretation.

Sampling

Quarries / Quarry Groups

In Phase I of this project, 50 samples from 20 sites were analyzed. The number of samples collected from individual quarries ranged from 1 to 5. Two true groups or geographic clusters of quarries were utilized: Uwharries 1 and 2. The remaining groups actually consist of individual quarries. The sampling in Phase II is intended to improve upon the Phase I sampling by clarifying analytical units and/or simply increasing the sample size and the number of quarries represented. In Phase II, we plan to employ the same general combination of groups and

individual quarries with a few modifications to group definition. Three criteria will be used to collect quarry samples and define groups for analysis:

1) Geography. Each quarry or quarry group reflects a discrete area meaningful to modeling lithic conveyance by prehistoric cultures.
2) Geology. All samples in a group or from a particular quarry are of the same mapped rock type.
3) Sample Size. A minimum sample size of 6 specimens is required for each quarry or quarry group, per Speakman and Glascock's recommendations in conjunction with their discussion of Principal Components Analysis.

Developing a sampling scheme to fit these criteria and to adequately address the research objectives for Phase II results in the group definition and sampling outlined in Table 1 (See Figure 1 for a map of Phase 2 quarries and quarry groups). Criterion 1 requires no modification of the original groups. Criterion 2 requires removal of Horse Trough from the Uhwarries 1 group into a separate, new group. Furthermore, since the remaining Uwharries 1 samples fall within 1 of 2 mapped geologic formations (Cid and Tillery), this group is divided into these respective formation groups. Criterion 3 requires the addition of 15 samples as noted in Table 1.

In addition to the above changes or additions to the Phase I sampling, a new quarry group is being added. Located in Orange County and consisting of two newly documented quarry sites, the Orange County group fills a geographic void between the Chatham County and Person County quarries. This addition expands our spatial coverage of the Slate Belt and adds an interesting source to the study. The stone from Orange County is a plagioclase and quartz porphyritic rhyolite.

Table 1: Quarry/Quarry Group Sampling Strategy, Phase 2 Lithic Sourcing.

Site	Source	Mapped Rock Type	Original Sample	Additional Samples
Uwharries 1a (Cid Formation)	Quarry	Rhyolitic Rocks	7	0
Uwharries 1b (Tillery Formation)	Quarry	Rhyolitic Rocks	12	0
Uwharries 1c (Uwharrie Formation)	Quarry	Rhyolitic Tuffs	2	4
Asheboro	Quarry	Felsite/Felsic Volcaniclastic	5	1
Chatham Ia (Ch729)	Quarry	Argillite	4	2
Chatham Ib[1] (Siler City)	Riverbed	Argillite	4	0
Chatham II (Ch741)	Quarry	Crystal Tuffs	4	2
Cape Fear	Quarry*	Metavolcanic-Epiclastic Rocks	4	2
Person Co. (Pr115)	Quarry	Felsic Volcanics	4	2
Durham Co. (Dh703)	Quarry	Crystal Tuffs	4	2
Orange Co.	Quarry	Felsic Igneous Complex	0	6
Totals			*46*	*21*

[1] The Siler City sample does not represent a quarry site, hence its separation from Chatham Ia which is an intensive and extensive quarry. Because the two locations are both mapped as argillite, they are included as subsets of one group. Due to the non-archaeological context of the Siler City site, no additional samples will be taken from that location, however the original sample data will be analyzed as part of this phase.

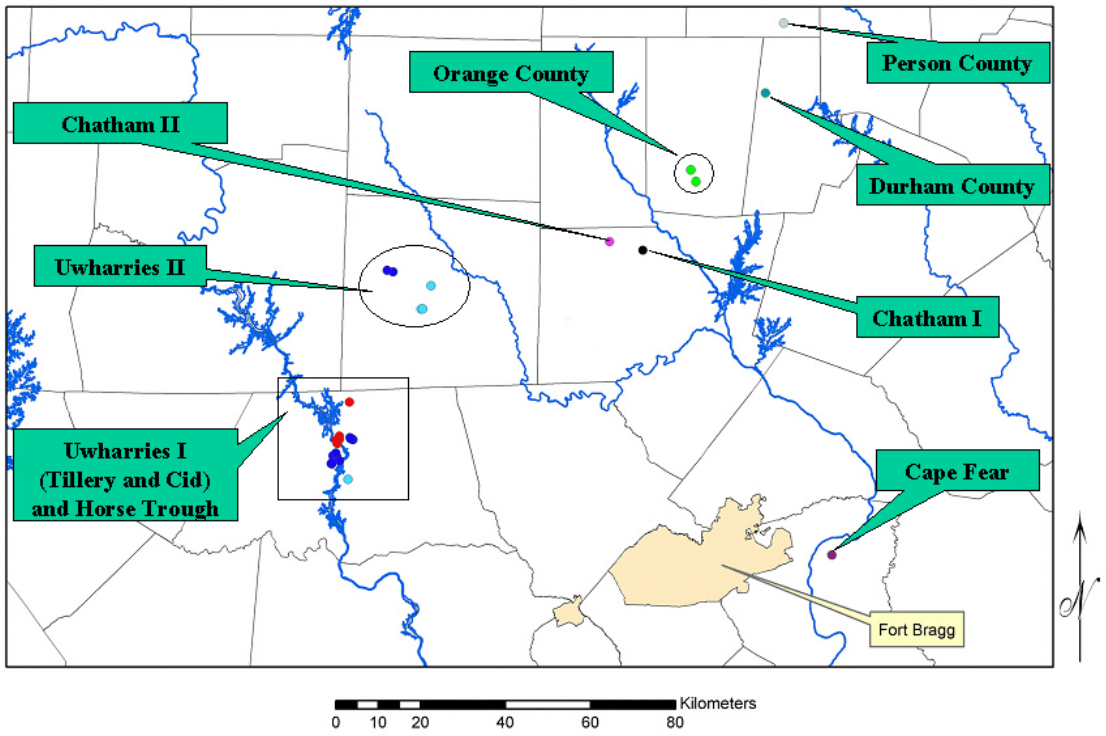

Figure 1: Quarry Groups.

It is imperative that the quarry sampling process includes factors of archaeological relevance. Specifically, sampling should concentrate on quarries or outcrops where prehistoric use of stone in the immediate area is evident. In cases where additional samples are required for a quarry or group, such samples may be taken from previously un-sampled sites, provided the sites meet criteria 1 and 2. In every case, consulting geologists should work with Fort Bragg CRP staff prior to fieldwork and sample collection. Every effort should be made to include a project archaeologist and geologist on sample collecting trips. It is recognized that the expertise of geological consultants will also be necessary to identify similarities or differences in the lithologic units within a specific quarry or outcrop. These factors may also determine the selection of specific samples. At the time of sampling, individual specimens will be recorded as an artifact or natural specimen. Prior to processing, the samples shall be photographed and labeled with appropriate provenience information and sample numbers.

Artifacts

The completion of Phase 2 sampling and analysis for quarries is expected to contribute significantly towards characterizing variability in quarries. To conduct a preliminary examination of variability in lithic composition of artifacts and the potential to associate artifacts with rock types, a limited number of artifacts from Fort Bragg will be analyzed. An anticipated 9 samples (actual number is contingent upon availability of funds), will be subjected to the same suite of analyses as quarry samples (see below). Three criteria will be employed to select artifact samples:

1) The total artifact sample comprises primarily metavolcanic material with macroscopic properties consistent with a quarries or quarry groups studied in this project. At least 2

artifact specimens will exhibit macroscopic properties thought to be inconsistent with quarry samples.

2) When and if possible, artifacts with temporal affiliation will be selected. The artifact will be either temporally diagnostic or associated with a well-defined archaeological provenience with some relative or absolute date.
3) Each artifact will meet a minimum size requirement established by consideration of all methods being applied. A range of artifact sizes may be used to evaluate the potential problems associated with artifact processing for this kind of study.

Criterion 1 encourages selection of artifacts representative of a range of variability, potentially comparable to the range exhibited in the quarry data but also indicative of the potential for unknown quarried material. It should be noted that, among lithic artifacts found on Fort Bragg, hafted bifaces are most likely to offer the greatest range of variation in raw material types. As the most highly curated elements in prehistoric toolkits, these artifacts are the most likely to be transported long distances before discard or loss. This consideration obviously relates to Criterion 2 as well. The primary intent of Criterion 2 is to add meaning to the information derived from establishing lithic provenience for an artifact. Without temporal context an artifact lacks cultural context. Criterion 3 reflects a basic practical requirement and an essential unknown at this point in the study. Defining the minimum size requirements for individual techniques and the sum total of techniques used is critical for future application.

The number of artifact samples slated for analysis is nine, bringing the total number of rock specimens analyzed in Phase II to 30.

Analytical Techniques

In Phase I of this project, three independent analyses were conducted. Stoddard analyzed the mineral content and classified the stone specimens according to rock type. Speakman and Glascock subjected the samples to INAA and performed a Principle Components Analysis using the trace element data to attempt group discrimination. Miller derived Nd-Sm isotope data from the samples and compared the values to distinguish groups. Miller also conducted a limited analysis of rare earth elements derived from stone samples.

While INAA was employed in the first phase to produce trace element data, the absence of major elements from this process precludes a complete assessment of the organic relationships between the petrography, Nd-Sm isotopes, and the chemical composition of the stones being studied. In order to produce a more comprehensive data set for rock chemistry, X-Ray Flourescence (XRF) will be used in this Phase to produce major element data, e.g., SiO2, Tio2, Al2O3, Fe2O3t, MnO, CaO, Na2O, K2O, P2O5, LOI, as well as trace elements. All samples, including the 30 new samples from Phase II and the 46 original samples from Phase I (See Table 1), will be analyzed by XRF. To derive additional trace elements and rare earth elements, e.g., Th, Hf, Sc, Ta, all samples will be analyzed using Inductively Coupled Plasma Mass Spectrometry (ICPMS). Finally, to ensure consistency between Phase I and II samples, the Phase II samples will be subjected to the same petrographic analysis, Nd-Sm isotope analysis, and INAA as the Phase I samples. The same consultants used in Phase I—Stoddard, Miller, and Speakman and Glascock, respectively, will conduct these analyses. The MURR laboratory will conduct the INAA, ICPMS, and XRF analyses and Speakman and Glascock will analyze the cumulative results of INAA and XRF for all samples, including Phases 1 and 2.

With the submission of specimens to each consultant, a copy of this research design will

be made available. Each consultant shall be made aware of the two primary research problems: discriminating quarry sites/groups and exploring the potential to provenience artifacts with the quarry data.

After chemistry data from MURR and accompanying analyses by Speakman and Glascock are submitted, other project team members may access all data sets for analysis. Such analysis is expected to benefit the exploration of relationships between the different data sets, e.g., Nd-Sm isotopes and rare earth elements, mineralogy and chemistry, etc. In addition, a quantitative analysis of the multiple data sets will be conducted to explore the most effective methods for classifying quarry data, discriminating quarry sites or groups, and examining the geologic affinity between quarries and artifacts.

REPORTING

A final report will be produced as an edited volume with contributions by individual consultants and project team members. This report will summarize the cumulative results of Phases 1 and 2 of this project. Emphasis shall be placed on description of research objectives, presentation of data and results, synthesis of independent analyses, and interpretation of the results for managing archaeological sites at Fort Bragg. A preliminary report outline is presented below, with tentative authorship noted. The report will be co-edited by Irwin, Webb, and Steponaitis.

Preliminary Report Outline

I. Introduction (Irwin, Britt, Webb)
- A. Project History and Key Players
- B. General Objectives

II. Research Design
- A. Background (Irwin and Moore)
  1. Archaeology of Fort Bragg
  2. Archaeological Treatment of the Carolina Slate Belt
- B. Research Problems (Irwin)
- C. Methodology (Irwin, Moore, and Webb)

III. Data Collection
- A. Geology of the Project Area (Stoddard and Miller)
- B. Quarries (Moore and Irwin)
- C. Artifacts (Irwin and Moore)

IV. Analysis (Stoddard, Miller, Speakman and Glascock)
- A. Consultant Reports
  1. Petrography
  2. Geochemistry
  3. Neodymium Isotopes
  4. Summary
- B. Synthesis and Analysis (Irwin, Moore, and Webb)

V. Conclusions
- A. Project Summary (Irwin and Moore)
- B. Methodological Implications (Irwin and Moore)

C. Lithic Provenience and the Sandhills (Irwin and Moore)

VI. Appendix: Guide to Stone Identification

CURATION

Fort Bragg will be the final repository for all thin-sections, thin-section blanks, and hand samples produced in the course of this project. Fort Bragg will maintain a type collection for all samples analyzed in the project.

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