

2d. PROJECT DESCRIPTION

The Problem

The Bonito phase (ca. A.D. 850 to 1140) in Chaco Canyon, New Mexico, is one of the most prominent – and debated - examples of rapid social transformation in the prehistory of North America (Altschul 1978; Crown and Judge 1990; Kohler 1998; Lekson 1999; Neitzel 1999; Mills 2002). Within a very short period of time, perhaps only one to two generations, a regional population of dispersed farming households gave rise to aggregated settlements socially anchored by a dense cluster of massive stone buildings in Chaco Canyon called “great houses.” Labor estimates for the construction of individual great houses exceed several hundred thousand man-hours (Lekson 1984) and bear testimony to the unprecedented amount of energy and organization that marks a shift from small undifferentiated social networks to large segmentary corporate groups (Sebastian 1992; Kantner 1996; Saitta 1997). Archaeologists have studied this striking change for more than 100 years and since the 1940s have known with considerable confidence the span in calendar years during which great houses appeared. Nonetheless, the processes that characterized the transition from one organizational form to the next remain stubbornly opaque, in large part because there are only a few great houses where an earlier occupation can be discerned and in these cases the tremendous amount of 11th century construction obliterated or buried the initial phases of development. Consequently, while researchers have devoted considerable effort to understanding the role or function of great houses in their final or completed form (e.g., Cameron and Toll 2001; Renfrew 2001), discerning the socioeconomic “roots” of the Bonito phase remains one of the most pressing problems in Chacoan archaeology (Judge et al. 1981:91; Cordell and Judge 2002:4; Varien 2001:51-52; Windes and Ford 1993:75; Windes et al. 2002:20-21).

Archaeologists refer to this period of incipient great house development as the “Early Bonito phase” with a time frame of ca. A.D. 860 to 1040ⁱ, followed by the Classic (A.D. 1040 to 1120) and Late Bonito phases (A.D. 1120 to 1220). The widely recognized hallmarks of the Bonito phase, including massive labor mobilization devoted to architectural construction and caches of ritual objects, are mainly associated with the Classic and Late Bonito phases. The socioeconomic character of the Early Bonito phase is much more uncertain and consequently researchers have been unable to determine whether the Classic phase was the product of autochthonous development in the canyon, immigration or some combination (Judd 1964; Judge, et al. 1981; Vivian 1990; Windes and Ford 1992; Windes 2003).

Nevertheless, among Chaco scholars there is widespread agreement that the origins of the Bonito phase can be found in a causal relationship between population growth and agricultural production. The prevailing view is largely convergent with an historical scenario presented by Judge and colleagues (1981), who argued that prehistoric crop cultivation in the Chaco region was an extremely risky endeavor, with the likelihood of adequate yields compromised by high levels of aridity, spatially and temporally variable precipitation patterns, short growing seasons, poor arable soils, and rudimentary

agricultural technology. Due to its large watershed, Chaco was always a relatively better agricultural location than surrounding areas, but farmers in the canyon would still have experienced periodic food shortages and economic stress due to stochastic environmental fluctuations (Judge, et al. 1981:77; also Schelberg 1992; Cordell 1997). Population growth during the Early Bonito phase forced farmers to intensify agricultural production by expanding fields into “marginal” zones, even in the more favorable confines of Chaco Canyon. Once this expansion occurred, subsequent shifts to better climate patterns, particularly increased precipitation, reduced the risk of crop failure in general and thus lead to greater effective yield and further population growth. The 10th century was a time of greater than average precipitation and Judge, et al. (1981:89) suggest that agricultural production followed this change monotonically. Thus the primary emergent condition for the Early Bonito phase was population growth due to an advantage in agricultural production factors compared to other parts of the Chaco region. Great houses were built in response to the potential economic and political power associated with surplus production, as storage facilities, centers of political power, community administration, and ritual performance.

This basic model has been the foundation of subsequent reconstructions of Early Bonito phase economics (Lekson, et al. 1988; Schelberg 1984, 1992; Sebastian 1992; Windes 1992; Windes and Ford 1993; Windes, et al. 2002). However, despite the general acceptance of demographically induced agricultural intensification as a likely feature of the Early Bonito phase, the demographic character of this period and the nature of agricultural production are essentially unknown. There are several reasons for this, all stemming from a lack of empirical data. Archaeologists have identified substantial Early Bonito phase occupations at just three great houses – Pueblo Bonito, Una Vida and Penasco Blancoⁱⁱ - and only Pueblo Bonito has extensive excavations that include this early phase of building and habitation. The Early Bonito phase rooms at Pueblo Bonito were excavated almost entirely in the late 19th century and although they were often filled with post-occupational debris, there are literally no data that can be reliably associated to the initial occupation of this part of the site except architectural details and tree-ring dates obtained by later researchers (Windes 2003:20). In the 1920s the National Geographic Society probed beneath the plazas at Bonito and encountered deeply buried pit structures and midden deposits dated to the 9th and 10th centuries by associated ceramics, but again no information other than pottery was recorded (Judd 1954, 1964). Excavations at Pueblo Alto in the 1970s encountered limited deposits associated with ceramics from the late A. D.900s or early 1000s, but only two room foundations. Several sites outside the canyon have Early Bonito phase components but these have not been excavated and data mainly represent descriptions of surface ceramics (Windes and Ford 1992; Windes, et al. 2002). The lack of modern excavation at great houses in Chaco occupied during the Early Bonito phase means that there has been almost no opportunity to examine the physical components directly associated with the initial emergence of great house settlements.

Chaco specialists have attempted to fill this empirical void with comparative data from non-great house sites, especially a group of four “small sites” excavated in the 1970s in Marcia’s Rincon near the Una Vida great house approximately 10 km east of Pueblo

Bonito (McKenna and Truell 1986; Windes 1993). These sites consisted of one-story buildings of 10 to 16 rooms, estimated to have housed 3 to 4 families or about 20 to 25 people, and are typical of 373 small sites in the canyon assigned to the Early Bonito phase (Hayes 1981). Dating indicates occupation during the Early Bonito phase but stratigraphic studies demonstrate complicated site histories that might reflect continuous occupation for several generations, multiple episodes of year-round occupation over long spans, or seasonal use during undetermined intervals. This ambiguity is typical of the archaeology of small farming settlements in the prehistoric northern Southwest and does not reflect on the excavators' skill. However, it does make it difficult to identify precisely the material in these small sites that was associated with the Early Bonito phase in the canyon, as noted by Chaco scholars (Hayes 1981:50; McKenna and Truell 1986:24, 37; Vivian 1990:214-218; Windes 1993:405-407; Bustard 1996).

The sparse information from the Early Bonito phase occupations at great houses and the limited ability to relate data from contemporaneous small sites to these occupations are severe impediments to gaining a better understanding of the economic processes underlying great house formation. The two critical variables involved in any sort of agricultural intensification are the organization of labor and production (Netting 1990; Kohler 1992; Kohler and Van West 1996; Stone 1992; Stone and Downum 1999), neither of which has yet been specified for *any* portion of the Bonito phase (see Cameron and Toll 2001; Earle 2001). Demographic reconstructions for the Early Bonito phase consist only of population estimates based on room numbers and/or room size, with widely varying figures resulting from different interpretive conventions (e.g., Vivian 1990:441 and Bernadini 1999:457). None of these figures suggest an unusually high population relative to other parts of the northern Southwest at the same time (Schlanger and Wilshusen 1993; Duff and Wilshusen 2000), and indeed, many researchers favor surprisingly small estimates given the amount of labor required for construction (Neitzel 2003; Windes 2003). Limited excavation data, small sample sizes, and poor temporal control confound efforts to calculate moving or momentary population estimates comparable to better studied areas, but a small residential population during the Early Bonito phase draws attention to a possible role for immigration during the transition to the Classic Bonito phase, although researchers have only been able to address this issue in speculative ways (e.g., Judge, et al. 1981:78; Vivian 1990:472-474).

Similarly, the nature of Early Bonito phase food production has been hard for archaeologists to reconstruct except in qualitative terms. Archaeobotanical data from well-excavated small sites indicate a "normal" range of cultigens and garden volunteers, with maize forming the expected staple crop, but otherwise offer no clues about diversity, productivity or production technologies (Toll 1985). Soil characteristics in the canyon do not appear to be very good for agriculture (Judd 1954:10-13) and modern growing experiments suggest the need for intensive cultivation to insure crop success (Toll, et al. 1985). Hence the general perception of Chaco as a marginal place for farming (Sebastian 1992; Renfrew 2001), a view that has stimulated important new research on the possibility that canyon residents imported food from outlying areas (Cordell, et al. 2001; Benson, et al. 2003).

Exchange systems predicated on variable inter-community economic production due to high-risk environments for food production dominate nearly all current attempts to delineate Bonito phase economics (e.g., Lekson, et al. 1988; Judge 1993; Cameron and Toll 2001) but recent studies of canyon hydrology paint an increasingly complex picture of local production conditions in this time period. Regional tree-ring records, pollen, and alluvial sequences, reflect average precipitation between A.D. 900 to 1025 (most of the Early Bonito phase) with high temporal variability and low spatial variability in precipitation, conditions favoring lowered groundwater levels, which would have been disastrous for farmers (Dean 1993). But from A.D. 990 to 1090 there were three major episodes of increased precipitation, and at ca. A.D. 1025 a regional shift to lower temporal and greater spatial variability occurred, favoring a rise in water tables. Dean's reconstruction is supported by Vivian's (1992) calculations for water use in Chaco during the height of occupation and construction, which exceed one million liters of water per day for agriculture alone during the growing season. New hydrological research in the canyon by Force, et al. (2002) posits the presence of a natural dam at the far western end of the canyon that had the effect of raising the water table for the entire canyon when surface water was impounded, and lowering groundwater levels when the dam was breached. According to this reconstruction, groundwater rose rapidly between A.D. 1025 and 1090, the beginning and peak of the Classic Bonito phase, when the dam was functioning. Flooding then filled channels throughout the canyon and led to floodplain aggradation (Force, et al. 2002:6; also Love 1983). Dean (1993:38) noted that new sediments would have renewed arable soils and "high alluvial groundwater levels would have relegated precipitation to secondary importance in crop production."

If water and sediment were flowing into Chaco in huge amounts by the end of the Early Bonito phase then it is possible that researchers are faced with a very different sort of socioeconomic incubator for the Bonito phase than simple environmental marginality. Agriculture in the canyon might have been released from the twin constraints of aridity and soil depletion, creating conditions for high potential productivity and enhanced productivity may have made Chaco attractive to immigrants; new sources of labor could have even have promoted recruitment efforts by canyon residents (see Stone 1992; Kohler and Van West 1996). The combination of heightened natural productivity and larger labor pools could actually have increased marginal returns *and* yields, in contrast to a Boserupian version of demographically stimulated intensification (resulting in diminished return rates) that underlies current economic models for the Bonito phase (see Stone and Downum 1999).

However, for the moment the comparative merits of these basic economic alternatives (and variants of each) cannot be adequately evaluated. In order to begin such an evaluation there needs to be new data and associated analytical studies drawn from cultural deposits at great houses that span the Early Bonito phase and transition to the Classic Bonito phase. Attempts to use poorly documented collections for complex questions, such as efforts to source maize in Chaco to possible outlying production zones (Benson, et al. 2003) have generated potentially exciting insights that are handicapped by unavoidable chronological and contextual ambiguity. Without modern investigations of the economic foundations for the Bonito phase, scholars will likely continue to conflate

the emergence of great house settlements with conditions that obtained during later periods of occupation, an extrapolation presumably to be avoided.

In summarizing recent work on Chaco Canyon, Cordell and Judge (2001:9) write that “we are weary and wary of grand stories and scenarios that go unevaluated,” and they urge their colleagues to obtain data that can be used to “provide solutions to ambiguities and reality checks for archaeo-mythologies.” These sentiments are echoed by Mills (2002) and Varien (2001), who observe that researchers are rapidly generating a vastly richer set of theoretical statements about Chaco than can be assessed with the empirical record. It is the goal of the research outlined in this proposal to respond to these calls for more information about the Bonito phase. New data will not solve all the issues that are now being debated, but they should give researchers a firmer basis for judging and constructing explanatory models about great house emergence. Any improvement in explanations for the Bonito phase will enhance the comparative utility of the Chaco case for understanding ancient episodes of rapid social transformation elsewhere, as suggested by Kohler, et al. (2000), Feinman (2000) and Yoffee (2001).

Research Plan

Funding from NSF is requested to support new stratigraphic and geoarchaeological studies of cultural and natural deposits at Pueblo Bonito that are associated with the Early Bonito phase and the transition to the Classic Bonito phase. Access to these deposits and any features contained within them will be provided by reopening extensive archaeological trenches originally excavated by the National Geographic Society in the 1920s (Fig. 1). These trenches revealed dense and complex strata resulting from the simultaneous deposition of cultural material (including household debris and construction waste) and natural alluviation on the floodplain where Pueblo Bonito is located (Bryan 1954; Judd 1964). Ceramics obtained from strata underneath the walls and rooms of Pueblo Bonito indicate the presence of Early Bonito phase and older deposits (Judd 1924, 1964; Windes and Ford 1992; Windes 2002) but this was the only information recovered from these trenches (Roberts 1927). The proposed project will allow the trench profiles to be described by modern geophysical methods and systematically sampled for a wide variety of data relevant to Bonito phase economies and environment.

These new data will be used to address the following broad goals:

- 1) The formation history of the deposits and features exposed in trench walls.
- 2) Characterization of the individual stratigraphic units in terms of content.
- 3) Interpretation of deposits and features with respect to economic activity and environmental context.
- 4) Identification of future research issues.

Trench Descriptions.

The archaeology of Pueblo Bonito is known primarily through the large-scale excavation of rooms conducted in the 1890s by the American Museum of Natural History (Pepper 1920) and the National Geographic Society in the 1920s (Judd 1954, 1964). However, both projects tested areas around the site, particularly the two mounds south of the pueblo. The number, location, and dimensions of these exploratory excavations during the AMNH research is uncertain, although photographs of trenches in the mounds exist. In contrast, the locations of many (but not all) of the NGS extramural excavations are well-known (Fig. 1). Detailed profiles of three trenches through the south mounds and the west plaza at Bonito were published (Judd 1964) and indicate a very complicated depositional history (Fig. 2).

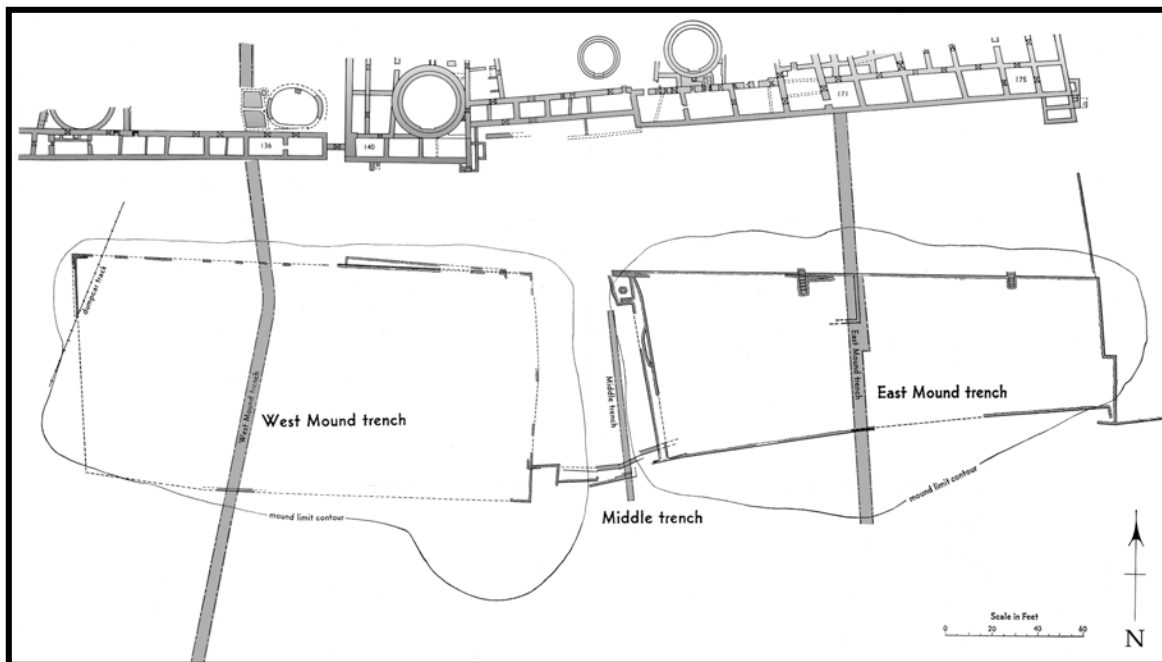


Figure 1. Three major trenches (shaded) excavated through the East and West mounds at Pueblo Bonito by the National Geographic Society between 1921 and 1925.

Judd (1964:212-222) described several types of buried deposits, including alluvial and aeolian sediments, household middens, and disposal of construction debris (masonry, adobe, timbers). Masonry walls associated with the Classic Bonito phase were built around the perimeter of both mounds, possible room foundations were encountered in the north-central portion of the East Mound flanked by stone steps (Fig. 1), and a number of prepared adobe surfaces were discovered in the upper fill of both trenches. Dating of all deposits and features is uncertain due to the uncontrolled trench excavations (Windes 1987). However, researchers noted several deeply buried distinct “dumps” of household debris that contained only pre-Classic ceramics (Roberts 1927:59; Judd 1964:211; Fig. 3 this proposal) and these features suggest that Early Bonito phase deposits may be distinguishable in the cross-sections.

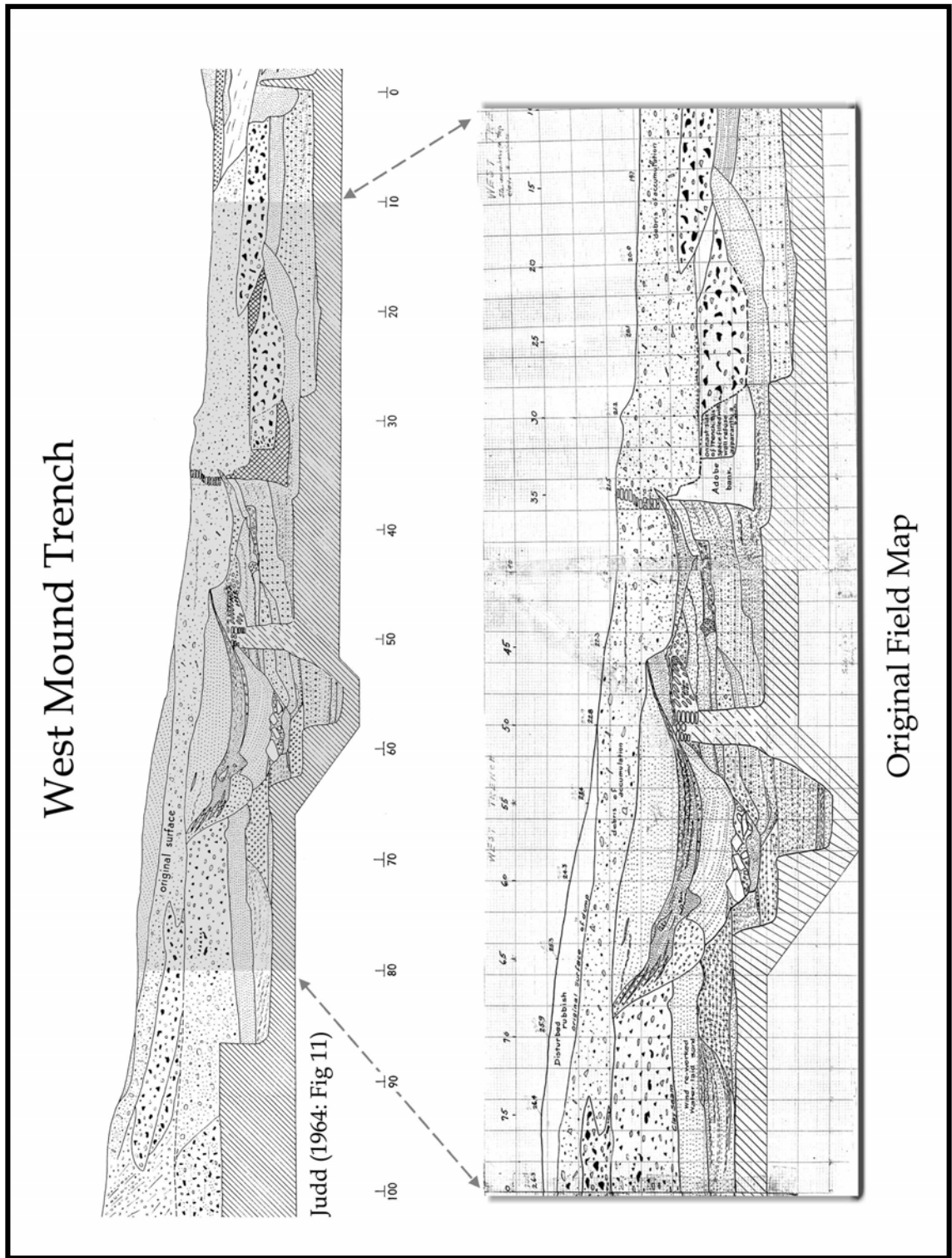


Figure 2. Stratigraphic cross-sections of the West Mound trench (top). Unpublished field maps (bottom) include text descriptions not present in published drawings, as well as details about layering and constituent materials (Smithsonian archives). The ditches described by Kirk Bryan are found between markers 30 and 70; the adobe bank is located between markers 30 and 35.

All of the archaeologists and geologists who worked at Pueblo Bonito from the late 19th century through the 1920s noted the extensive physical evidence for alluvial deposition in the buried deposits around the site (Pepper 1920:23-24; Roberts 1921:32-47; Judd 1964:222). This evidence consisted of channels, gravel deposits and laminated silts and clays. However, it was Kirk Bryan, the noted Quaternary geomorphologist, who provided the most detailed description of features that are possibly the remains of Bonito phase irrigation systems.

In 1921 Mr. Judd dug a trench 20 feet in depth to study the stratigraphy of the west refuse mound at Pueblo Bonito. Four years later when he extended it out into the flat fronting the mound, the trench cut across several obviously artificial canals or ditches. They ran parallel to the front of the refuse mound and, therefore, essentially east and west. They were from 4 to 10 feet wide and were enclosed on the downhill (south) bank by walls of slushed mud (adobe) laid with care in places supported by the dumping of house refuse. Filled with both fine and coarse materials, including Late Bonito potsherds, these ditches presumably had carried floodwaters from upcanyon, perhaps from the Rincon of Chetro Kettle, to fields west of Pueblo Bonito. As each filled up or was washed out, a new one was constructed along the same route. Such more or less temporary ditches for the spreading of water are fairly common features of floodwater fields in New Mexico. If these before Pueblo Bonito were more elaborately constructed than is usual, it is doubtless because they lay close the village were labor was readily available (Bryan 1954:45).

Figure 3 is a copy of Bryan's field notes showing the location of these ditches, which can also be seen in Judd's published profile and field map of the west mound trench (Fig. 2).

Judd (1964) did not call attention to Bryan's interpretation, but he did describe a 30 foot wide "former watercourse exposed by our East and West Mound trenches" (1964:221) that seems likely to have been the watercourse noted by Dodge (quoted in Pepper 1920:24) at a depth

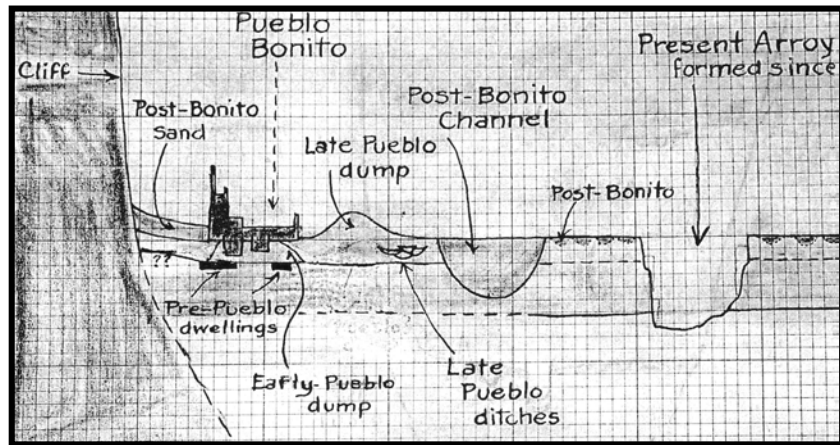


Figure 3. Original field map by Kirk Bryan (Smithsonian archives).

of 10 feet in a trench excavated by the AMNH in the East Mound. Judd (1964:150; field notes) also described "an undeniable watercourse" 24 feet in width and 10 feet deep exposed in the Far East Trench in the Northeast Foundation Complex; this watercourse is on the same alignment as the ditches described by Bryan underneath the Bonito mounds.

The likelihood that buried irrigation canals were exposed in the NGS trenches has important significance with respect to the argument by Force et al. (2002) that groundwater levels were rising from the end of the Early Bonito phase until the end of the 11th century. High water tables would have facilitated irrigation, but rising ground water and floodplain aggradation may have buried canals and rendered them inoperable.

Bryan (1954) obviously thought this had happened although he did not know when. One possible response by Chaco farmers could have been to shift fields to higher locations, such as the canyon side tributaries. In short, hydrological conditions during at the end of the Early Bonito phase may have been extremely favorable for irrigation farming around Pueblo Bonito but rising water eventually destroyed the canal system. Whether this historical scenario proves accurate or not, the presence of large-scale water control during the early Classic Bonito phase would require a substantial revision in current economic models for Chaco.

Data Collection and Analysis

The program for collecting, analyzing and interpreting data from the Pueblo Bonito trenches, is designed to address the following issues that are central to the problem of agricultural production during the Early Bonito phase.

- 1) Identification of Early Bonito deposits and features through dating methods.
- 2) Characterization of those deposits and features to allow a basic description for Pueblo Bonito and comparison to other sites excavated more recently in and around Chaco Canyon.
- 3) Improved understanding of floodplain alluvial hydrology and possible human induced impacts around Pueblo Bonito.
- 4) Expansion of database for local environmental conditions during the Bonito phase.
- 5) Evaluation of possible irrigation features and other physical indications of agricultural activity.

Procedures.

The procedural approach to data collection and analysis will adhere to the following sequence of activities. *Each step after 1) will involve close collaboration between all members of the project so that all sample collection is coordinated among analysts.*

- 1) Locate, reopen and remove backfill from National Geographic Society trenches and tests. The following sections will be the initial focus of field studies; additional sections may be opened depending on circumstances.

West Trench: 0 – 50' (Judd 1964:Fig. 24; Fig. 2 this proposal)

Middle Trench: 0 – 20' (Judd 1964:Fig. 24)

East Trench: 120-190' (Judd 1964:Fig. 7)

- 2) Obtain visual stratigraphic descriptions and make records of all profile faces.
- 3) Obtain all relevant samples from profiles, including “conservation” samples that can be reserved for future investigations (Goldberg and Macphail 2003).
- 4) Leave trenches open for some period of time (to be determined in consultation with the NPS) to allow additional sampling in response to laboratory analysis and to permit other researchers the opportunity to view the trench profiles, or close the trenches in such a manner that they can be reopened easily for additional study.

- 5) Completion of basic analyses and dissemination of results.
- 6) Assessment of the need for, and feasibility of additional fieldwork.

Detailed Description of Methods.

1) Trench Reopening.

The specific goals for trenching are to remove the backfill from the trenches and expose the deposits and features in cross-section so that they can be described and systematically sampled by each analyst. There are no records for how the trenches were backfilled and consequently it is not clear what problems might be encountered in removing the fill. If relatively clean sediment was used there should be little difficulty in excavation but if the NGS archaeologists simply shoveled debris back in, which would include stone rubble, adobe fragments and other clastic material, then the reopening could be very complicated. The project is designed to accommodate this uncertainty by allowing extensive removal of sediment if conditions permit and more limited excavation in one or two key portions of the trenches if fill material presents challenges. The permit from the NPS is for two years (2005-2005) and three separate field sessions so that there are opportunities to assess progress and make changes in field methods as necessary.

It seems certain that the original profile faces shown in published diagrams and field notes (Fig. 2) were disturbed by the backfilling and so the Park Service has given permission to clean back the trench walls to obtain adequate faces for analysis. Any wall cleaning will utilize natural strata or distinct features as excavation units. All material from the trenches will be excavated in arbitrary levels of 20 cm or less and completely screened through mesh of 1 cm or less, on the presumption that there may be interesting information in the way that the trenches were filled and that the fill contains artifacts and other informative material; a staff member from the NPS Chaco Collections and Archive will be present in the field to supervise all inventorying of materials from the trench work. Shoring systems will be employed under the supervision of a registered professional engineer whenever trench depth exceeds 1.8 m, as per federal safety regulations

2. Stratigraphic Descriptions.

The goal in describing the strata and features exposed in the trench profiles is to obtain an extremely detailed resolution of all visually distinctive variation in constituent materials that will form the basis for analytical sampling. Preliminary descriptions will be made as the fill removal progresses, but the working stratigraphy will be a joint effort by the project participants with the geologists taking the lead. An important aspect of this collaboration is to insure comparability between these analyses and previous geological work in the Chaco floodplain (Hall 1977; Love 1980, 1983; Force, et al. 2002).

General descriptions will follow guidelines suggested by Waters (1996) and others (Brown 1992; French 2003) for distinguishing among stratigraphic units. The definition of stratigraphic units will also utilize local criteria and conventions developed by

geologists for Chaco Canyon (Love 1983; Hall 1988). Stratigraphic descriptions will be made for all four walls in each trench (only the east wall was recorded by the NGS) using drawings, photographs (conventional and digital) and laser imaging.

3. Relative Dating.

The initial (or field) identification of Early Bonito phase deposits will rely on relative dating methods, including the association of temporally diagnostic ceramic types (Red Mesa Black-on-white especially). However, previous researchers noted a complex mixing of ceramic types in the trenches which they attributed to displacement by site inhabitants during construction events (Roberts 1927:60; Judd 1964:214-216) and it may be difficult to make accurate chronological assignments from profiles alone. Therefore it is likely that the initial temporal ordering of strata will draw on several lines of evidence, beginning with layers sealed by overlying features, such as wall segments, adobe surfaces, or channel deposits. For example, in Fig. 2 a collapsed wall has is overlain by apparent channel deposits, indicating that both the channel and fill post-date the wall, which in turn can be assigned to a post-A.D. 1020 date by masonry style and construction technique.

In addition to these relative methods, the project will submit samples of animal bones from distinct stratigraphic units for fluoride dating. Fluoride dating can determine the relative ages of specimens, and in conjunction with chronometrically dated materials may provide calendrical dates. Recent research in the Tucson Basin of southern Arizona has been successful in using fluoride dating to distinguish very fine chronological variation in pithouse occupations (Schurr and Gregory 2000). In this proposal the focus of fluoride dating will be an effort to evaluate whether the contents of discrete layers or deposits are the same age, which will offer insight to the origins of those units (e.g., whether material is mixed from different sources). This will be a limited portion of the overall research program and is intended in part to assess feasibility. If the results are productive, funding for additional dating of bone from Chaco collections will be sought.

4. Chronometric Dating.

Several methods will provide age assessments for individual lithostratigraphic units. The goals for chronometric dating include assignment of strata and features to different cultural periods (e.g., Early and Classic Bonito phases), determination of depositional rates, timing of channel cutting and filling and other geomorphological events associated with the floodplain in the vicinity of Pueblo Bonito. Accumulation rates are especially important in distinguishing depositional processes, and accurate estimates in large, complex archaeological sites require thorough chronometric assessment (Stein, et al. 2003).

The principal chronometric method will be Optical Stimulated Luminescence (OSL) which is now widely utilized for dating sediments deposited in conditions of light exposure. OSL is based on the sensitivity of some minerals, particularly quartz and feldspar, to emitting trapped electrons when subjected to light and sediments that cannot

be dated by radiocarbon method can be dated by OSL with a time range of 100 to 200,000 years ($\pm 10\%$). OSL has recently been used in archaeology to establish a chronology for rebuilding of prehistoric canals in Thailand (Sanderson, et al. 2003). OSL dating for this project will be conducted by Dr. Kenneth Leper of North Dakota State University who recently used OSL to date post-occupational sediments in the main channel of the Chaco Wash. This work produced temporally coherent sequences but the variation around the mean may not offer enough resolution for detailed archaeological questions. Nevertheless, OSL can provide key chronometric control for major depositional processes in the floodplain and therefore will contribute a critical piece to the overall alluvial reconstruction.

In addition to OSL the project requests funds for a number of AMS radiocarbon dates on annual plants or other similar material to provide further chronometric control and, if appropriate, dates on items of special interest (such as maize cobs). Previous work at Pueblo Alto in Chaco (Windes 1987) and the Bluff Ruin in Utah (Cameron 2002) suggests that the most profitable context for tree-ring dates in non-architectural situations will be where the remains of burned rooms or buildings were dumped *en mass*. Nearly all datable tree-ring specimens from Pueblo Alto came from a discrete deposit of burned timber and daub in the trash mound and Judd noted “refuse from the remains of burned houses” in his field drawings of both the East and West trenches. These sorts of deposits provide an important terminus post quem date for the stratigraphic section, as well as “packages” of material that probably originated together.

Dated stratigraphic units will allow subsequent sampling to target portions of the trenches that may have special significance for particular issues. For example, identifying floodplain deposits attributable to the Early Bonito phase can contribute greatly to ongoing efforts to identify agricultural soil characteristics in this period, which so far lack this temporal precision (Benson, et al. 2003).

5. Geomorphology.

Gaining an accurate alluvial history of the floodplain around Pueblo Bonito is fundamental to addressing the relationship between environment and agriculture in the formation of great house settlements. A key goal for the proposed research is an assessment of the Force, et al. (2002) model for canyon flooding during the Early Bonito phase.

The geomorphological investigation will build on the considerable body of work that has been done in the main Chaco Wash and tributary arroyos (Hall 1977; Love 1980, 1983; Force, et al. 2002). Data collection will include samples for grain-size analyses and clay mineralogy, as well as conservation samples that can be utilized for future studies. For instance, determining variability in trace element composition among depositional units may provide valuable controls for identifying source areas for crops (see Benson, et al. 2003). Among the questions that the geological studies will address immediately are whether Pueblo Bonito was originally built on a stable soil-forming landscape, the timing and rate of incision for the Bonito channel, the timing of channel filling, estimation of

discharge rates from buried water courses, and identification of any effects on the floodplain from cultural activities, such as the deliberate filling of channels with construction debris.

6. Paleoenvironments.

The primary goal of the project with respect to environmental issues is improving our understanding of floodplain habitats. Marginality models predict low plant diversity and possibly denuded surfaces, while models emphasizing mesic conditions and standing water suggest higher diversity, including aquatic plants and micro-invertebrates. Neither perspective can currently be affirmed on the basis of data from temporally relevant deposits. The project approach to acquiring new data brings together three dimensions of the paleobiological record – pollen, micropaleontology, and botanical macrofossils.

Pollen has been the mainstay of environmental reconstruction at Chaco (Hall 1977, 1988; Betancourt and Vandevender 1981; Betancourt et al. 1983) and provides a rich source of comparative data for new studies. Pollen records suggest a wetter climate than today between A.D. 1025 and 1090 in the San Juan Basin (Hall 1988; Dean and Funkhauser 2002:39-41). However, temporal resolution for existing pollen records during the Bonito phase is course-grained and does not allow comparison between the Early and Classic phases (Hall 1988:588) and thus an assessment of changes in vegetation that might signal changes in local floodplain habitats. Cully (1982:2) argues that pollen data from Chaco cannot offer the kind of temporal resolution archaeologists need to address most intra-site change but her data came from relatively small sample sizes and restricted site context and it may be possible to improve on this problem through large sample sizes from varying locations. Micro-invertebrates offer extremely sensitive indicators of local habitats, especially the presence, seasonality and flow rates of surface water (Palacios-Fest 1997) and have been previously utilized in Chacoan environmental reconstructions (Hall 1980). Plant macrofossils are particularly indicative of the presence of weeds (disturbed sediments, fields), local habitat diversity (including crop mixes), and artificial reduction in floodplain species through human activity (Minnis 1985).

7. Cultural Features.

The critical goal in the archaeological portion of the project is characterizing deposits and features associated with the Early Bonito phase (ca. A.D. 860 to 1040) with respect to economic activity, especially food production. Relevant data from these contexts will include subsistence remains, ceramics and other artifacts, and sources for materials (e.g., construction debris). Sample size is likely to be small for most artifact classes, given the limited excavation of profiles, but it should be possible to calculate density estimates for most material that can be compared to other more recent excavations, particularly the Pueblo Alto trash mound (Windes 1987; Toll 2001; Wills 2001).

A reasonable expectation is that reopening the NGS trenches will answer the question of whether adobe banks and apparent channel deposits are remnants of a buried irrigation system adjacent to Pueblo Bonito. If these features are artificial canals and associated

deposits, they can be analyzed in terms of likely discharge capacity, flow rates, and labor costs based on size, dimensions, and construction material (Mabry 1996). If they are something else, then alternative explanations will derive from contextual information. Integrated analysis of pollen, micro-invertebrates (mollusks and ostracodes) and plant macrofossils has been successful in identifying prehistoric irrigation systems in the Southwest, some more than 3000 years old (Damp, et al. 2002). Research in the Hohokam culture area of southern Arizona has been useful in interpreting canal function, seasonal use patterns, and differentiation of irrigation and non-irrigation deposits (Adams, Smith, and Palacios-Fest 2002). For example, main canals tend to have high pollen diversity, whereas feeder canals typified by low diversity and a dominance of cultigens such as maize. The presence of cattail pollen and micro-invertebrates signals slow-moving water, often associated with secondary or field canals; flow rates correspond to canal rank within an irrigation system. Micro-invertebrates are more plentiful in slow flow contexts and can also reflect episodes of salinization and refreshing in their chemistry, as well differences in winter and summer precipitation. Sediments from irrigation canals have shown a consistent relationship between texture and pollen/micro-invertebrates, with high sand percentages (high energy deposition) corresponding to low recovery rates and sediments with high organic content corresponding to abundant pollen, mollusks and ostracodes. In addition, reworked deposits (a clue to sediment source) can be identified by high percentages of eroded and damaged pollen and micro-invertebrates. Canal clean-out deposits are usually associated with burned plant parts (from weed clearing) and high percentages of weedy species. Recent research in the Near East also suggests that drought tolerance attributes in weeds such as epidermal cell size can discriminate between irrigated and non-irrigated fields (Charles et al. 2003), which can be evaluated at Chaco. In general, irrigation signatures are more complex when water sources include both stream flow and precipitation.

One alternative to irrigation might be that adobe banks were foundations for other structures, as suggested by Stein, et al. (2002). There is some disagreement about how the mounds in front of Pueblo Bonito were formed and reopening the trenches will allow researchers to obtain better descriptions of features such as walls and more exact inferences of the processes responsible for their growth. For instance, ongoing analysis of pollen samples from the Puebl Alto trash mound, which is not located in a floodplain environment, will provide comparative material for interpreting NGS trench depositsⁱⁱⁱ. It is not a primary goal of this project to evaluate competing ideas about mound function but it should be simple to generate useful new data in this regard.

Educational Component.

The project will seek to integrate research results with education in the following ways:

- 1) The University of New Mexico will sponsor a Web site that provides an introduction to the trenching project, including research questions and ongoing analytical results. The Web site will have two parts, one oriented toward professional audiences and college-level academic courses, the other toward grades K-12. Educational specialists from the

Maxwell Museum at the University of New Mexico will consult with the project in the design of the Web site.

2) The project will produce a series of four informational posters for use by the project and the National Park Service in describing the research effort to Park visitors. These posters will introduce a) the specific trenching effort at Pueblo Bonito, b) the alluvial geomorphology and history of the canyon, c) reconstructed paleoenvironments in Chaco Canyon, and d) the history of collaborative research between UNM and NPS at Chaco. Digital files have already been created for two of these posters. Posters and take-away pamphlets will be part of an interpretive kiosk located at the field site, attended by a student who will answer questions from visitors. The project P.I. will offer evening lectures for visitors during the field sessions and conduct a daily tour of the excavation for visitors.

4) The project will work with the Department of Native American Studies and the College of Arts and Sciences at UNM to provide research opportunities for Native American students.

Implications and Significance.

The Bonito phase has gained considerable attention in the archaeological community over the past two decades as an example of emergent social complexity that might offer insight into dynamics that promote rapid social change in small-scale societies (e.g., Sebastian 1992; Nelson 1995; Kohler 1998; Van Dyke 1999; Durand and Durand 2000; Mills 2002). Interest in the theoretical implications of Chacoan great house development extends beyond the Southwest to scholars whose research foci involve the evolution of social stratification, institutionalized exchange systems, and ritual sanctification as a route to political power (e.g., Neitzel 1999; Feinman 2000; Renfrew 2001; see Trawick 2001). However, at this point it is impossible to study directly the emergent processes responsible for the Bonito phase because there are so few archaeological data from this period in Chaco. This project proposes to increase the amount, quality and relevance of information about agriculture and local environments at Pueblo Bonito and in so doing offer researchers a substantial new basis for constructing explanatory models for the origins of Chacoan great houses.

ⁱ Throughout this proposal I use chronological periods established by the National Park Service Chaco Project (see Windes 2003).

ⁱⁱ Pueblo Alto has limited archaeological evidence for construction and possibly a residential occupation in the early 11th century, at the end of the Early Bonito phase (Windes 1987).

ⁱⁱⁱ A series of pollen and sediment samples from the Pueblo Alto mound has been analyzed by palynologists Suzane Fish of the Arizona State Museum and Susan Smith of Northern Arizona University, and the Soils Laboratory in the Department of Earth and Planetary Sciences, University of New Mexico. These data are being prepared for publication; preliminary results are reported in Wills (2001).

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