

# GPR Mapping to Test Anthropological Hypotheses: A Study from Comb Wash, Utah, American Southwest

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The GPR method allows efficient and accurate three-dimensional mapping of buried archaeological sites, which can be used to categorize and age date ancient architectural features. A site at Comb Wash, Utah was used to test the nature of buried remains within large surface depressions with GPR. Amplitude slice-mapping revealed aspects of architecture orientation, size and feature associations that are distinctive with respect to cultural affiliation and age. Hypotheses regarding prehistoric human behavior and affiliation were then determined and sites were placed within a historic framework. The large depressions at Comb Wash had been assumed to contain the remains of Great Kivas, large diameter semi-subterranean rooms, which elsewhere are known to have been used for ceremonies. These large structures are usually assumed by archaeologists to indicate a very strong affiliation to the dominant Chaco culture in New Mexico in the 11<sup>th</sup> and 12<sup>th</sup> centuries. Three of the four surface depressions were shown by GPR mapping to instead contain room blocks with small associated kivas, a pattern more typical of domestic occupations by one family or a very small group. GPR mapping showed that the Comb Wash area at this time was therefore more likely a rural agricultural community that had a much weaker affiliation with the dominant Chaco people to the south. These results necessitated an adjustment in ideas regarding the cultural history of this area, demonstrating GPR's utility as an anthropological tool for hypothesis testing.

## I. INTRODUCTION

Archaeologists have employed ground-penetrating radar for discovery and mapping of buried archaeological sites for many decades, often with good success [1]. Its utility to not only find, but project information from limited test excavations into a large area in three-dimensions is undisputed, and can be a method to readily discover and map prehistoric remains. The integration of geophysical data with more standard archaeological excavation data can now make GPR a tool for much more than just discovery and mapping. It can potentially test hypotheses about human behavior, study culture changes over time, and answer many other questions that are anthropological or historical in nature. This paper discusses one such study from southeastern Utah, U.S.A., where buried Puebloan sites from between A.D. 900 and 1300 were studied using GPR in order to test the integration of a regional economic, political and religious system known to many archaeologists as the "Chaco Phenomenon" [2].

## II. ARCHAEOLOGICAL BACKGROUND

The Chaco period of influence in the Four Corners region of the American Southwest, beginning about A.D. 900, is characterized by widespread and distinctive architectural styles that have been linked to a shared ideology [2]. It was during this time that many of the most impressive buildings were constructed such as those in Chaco Canyon New Mexico (Figure 1). These large structures are characterized by above-ground room blocks (called pueblos) and associated semi-subterranean circular pit structures termed kivas, which were used for ceremonial and other activities. Often during Chaco times these kivas and pueblos were "over-built" presumably to impress others, and are often referred to with the moniker "great" by archaeologists who study this region (Figure 2). Kivas that were very large and indisputably Chaco in origin are therefore termed Great Kivas. Chaco Canyon, in northern New Mexico contains the most impressive of these ancient Great Kivas and pueblos, and has always been assumed to have been the most influential cultural center at this time. Archaeologists have proposed many hypotheses about the way Chaco leaders might have exerted influence on the surrounding region, but there is no consensus among scholars as to why or how this was accomplished [3].

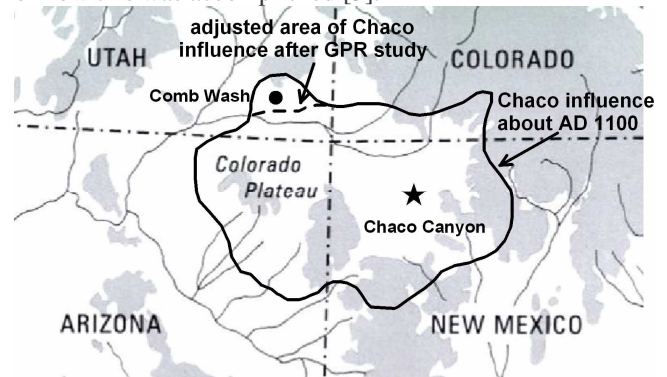


Figure 1: Area of GPR study showing Chaco cultural influence before and after the GPR study.

Usually when Great Kivas and other large buildings from the Chaco period are found at sites on the margin of the Chaco influence they are referred to as Chaco-outliers, and economic and religious connections with the Chaco center are hypothesized. Some scholars have proposed that the outliers represent military strong posts, or that the people living there were subsumed under a tribute and

redistributive system controlled by Chaco [2,4,5]. At Comb Wash, Utah (Figure 1) four large circular depressions were hypothesized to be buried Great Kivas, and based on this evidence. The area was thought to have been a regional center of Chaco integration, which was integrally tied to the larger center at Chaco Canyon far to the southeast [6]. To test these ideas GPR data were collected in large grids over these depressions in 2003. Previous work in the area had shown that the GPR method could produce images of buried kivas with good resolution [7]. The excellent resolution of these features in GPR reflection profiles is a function of the distinct interfaces between the stone walls and compacted earth and masonry floors with the sandy aeolian matrix, producing distinct radar reflections (Figure 3).



**Figure 2: An excavated Great Kiva in Chaco Canyon**

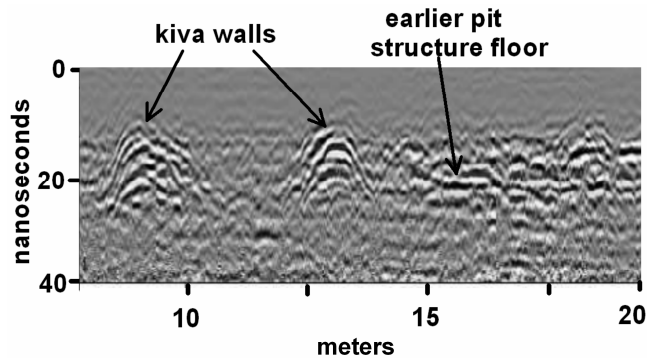
### III. GPR DATA ACQUISITION AND PROCESSING

Four GPR grids were collected on the Comb Wash depressions with antenna transects spaced at 50 centimeters. The GSSI SIR-2000 control system with 400 MHz center frequency antennas was used with 50 reflection traces collected per meter in time windows ranging from 30 to 50 nanoseconds. Reflection profiles show distinct vertical walls and floors of pit features (Figure 3). In all four grids amplitude slice-maps were constructed [1] in 5 nanosecond (two-way time) slices, each of which is approximately 30 centimeters thickness in depth.

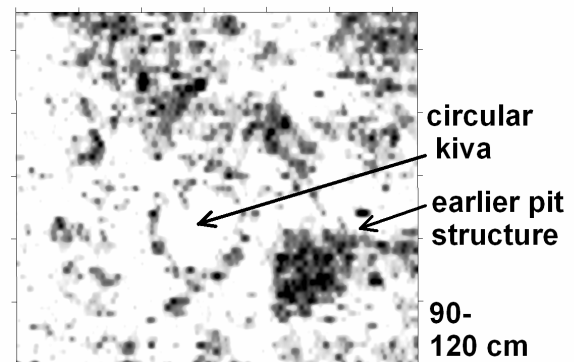
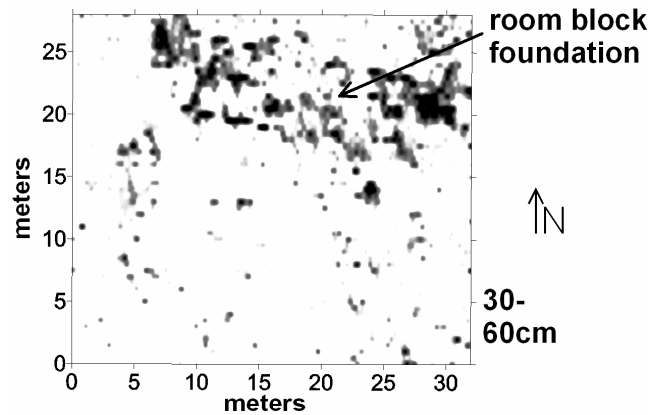
### IV. ANALYSIS OF DATA

It was anticipated that large circular amplitude features of Great Kivas would be imaged in this data processing method, mimicking the size of the surface depressions. These depressions range in diameter from 8-12 meters, which is the usual size of Chaco period Great Kivas elsewhere [7]. Instead the amplitude slice-maps yielded a much different picture of the buried sites. Two of the four sites (Sites 1 and 2) showed much smaller circular pit features ranging in diameter from 5 to 7 meters (Figures 4 and 5). At these two sites the GPR maps also showed a palimpsest of multiple pit features that are superimposed, indicating at least two, but potentially more periods of construction and modification of these architectural features (Figure 4). Site 3 showed only one pit feature

constructed into bedrock, also about 6 meters in diameter (Figure 6). The fourth test site yielded no features that could be identified as architectural whatsoever in the amplitude and the depression presumably is not archaeological in origin.



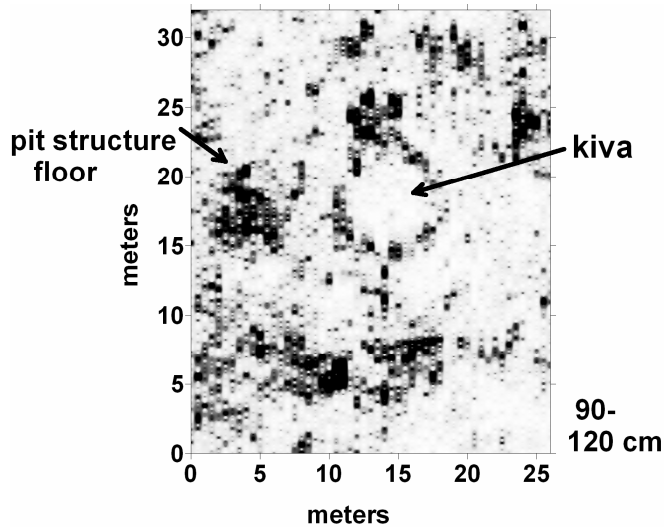
**Figure 3: Reflection profile showing kiva walls and an earlier pit feature floor.**



**Figure 4: Amplitude slice-maps of a shallow room block foundation and deeper pit structure floor and kiva walls at Site 1.**

To test the origin and age of the resulting GPR amplitude features at Sites 1 and 2, augers and standard open excavations were conducted. Vertical stone walls were uncovered in the locations where the highest reflection amplitudes were mapped, definitively showing that these are masonry-lined structures much like other excavated Great Kivas, but very much smaller. Ceramic artifacts

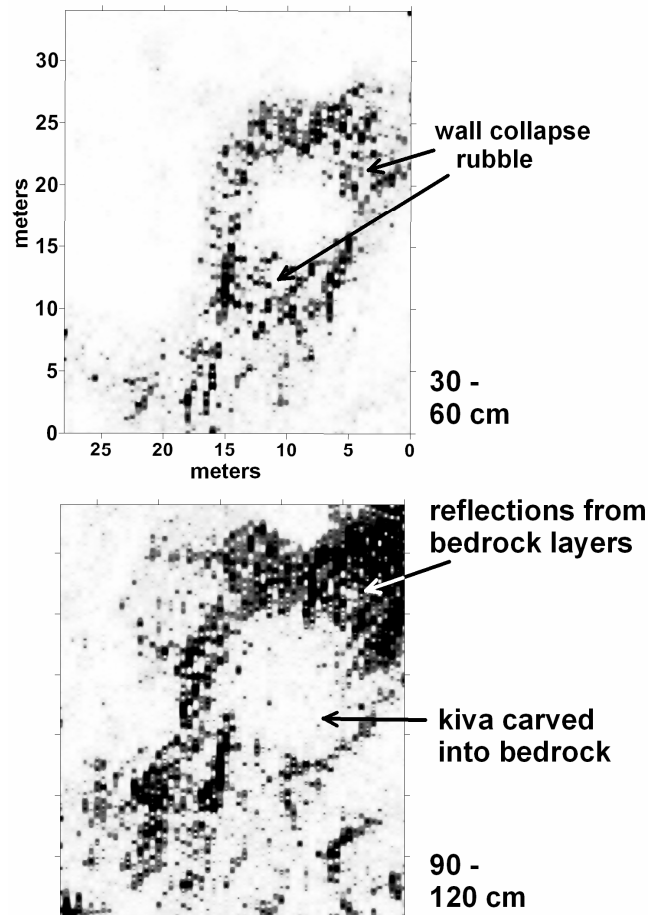
encountered in association with the floors of these structures date to both before, during and after the period of presumed Chaco influence in the area. These excavations also confirmed multiple phases of construction at these sites, which had been hypothesized from the GPR maps. At two of the sites at least 2 kiva and pit structure building and subsequent abandonment episodes over possibly a few centuries of time were demonstrated. Their small size and the abundance of everyday cooking artifacts and other utilitarian tools supports the hypothesis that these were kivas used for multiple functions and not just ceremonies.



**Figure 5: Amplitude slice-map of buried kiva and pit structure floor of Site 2.**

In addition to kivas and other pit features, GPR reflection data mapped the remains of small room blocks to the north of each of the underground kivas in the upper 50 cm (Figure 4). The remains of these larger stone features were partially visible on the ground surface as rubble piles, which had been assumed prior to GPR imaging to be the surface remains of buried antechambers connected to the Great Kivas have been described elsewhere in the area [8]. The GPR maps, however, showed no architectural elements preserved below the upper 30-60 centimeters in these areas, and the spatial patterning of the reflections in the upper slices show instead the foundations of above ground buildings that were composed of between 6 and 8 rooms each (Figure 4). These buildings likely served the habitation and storage functions for this small group of people.

Site 3 GPR mapping illustrated a kiva cut into bedrock whose walls had partially collapsed long after abandonment (Figure 6). No room block was seen in the GPR maps at this site perhaps because its stone building materials were originally set on bedrock had been recycled and re-used elsewhere long ago. The kiva at Site 3 was also 6-7 meters in diameter, indicative of a small group size.



**Figure 6: Amplitude slice-map of kiva cut into bedrock from Site 3**

## V. CONCLUSIONS

Closely spaced antenna transects and amplitude slice-mapping at a 30 cm thickness was a method capable of producing very accurate images of buried room block foundations, kivas and pit structures in southeastern Utah. When these reflection maps were tested using standard excavation techniques, age dates from pottery placed these architectural features into the cultural chronology of the region. The results showed that three of four large surface depressions seen on the ground surface, which were thought to contain Great Kivas, were actually the remains small family-sized settlements. These structures consisted of a small above ground room block with associated kivas and in two cases, earlier pit structures. Reflection profiles also showed evidence of multiple periods of building and renovation at two sites, indicating a long period of habitation by a small group of people. The presumed presence of the Great Kivas in this area of the American Southwest, which previously been considered evidence for a local area of Chaco influence, from AD 900 to about 1150 was refuted. Instead, the GPR mapping showed only three small utilitarian kivas and associated room block foundations of small farming settlements. The GPR

mapping was able to quickly and accurately refute the original anthropological hypothesis and instead support the idea that this area was more likely inhabited agricultural people living in small dispersed groups, with much less cultural connection to Chaco Canyon than was originally hypothesized.

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