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This study was done in cooperation with the Navajo Nation Historic Preservation Department, Chaco Protection Sites Program, the Chaco Culture Natural History Park, Aztec Ruins National Monument, San Juan County Museum Association—Salmon Ruins, and the University of Colorado

Sources of Ancient Maize Found in Chacoan Great Houses

BACKGROUND

Between the 9th and 12th centuries A.D., Chaco Canyon, located near the middle of the high-desert San Juan Basin of north-central New Mexico (fig. 1), was the focus of an unprecedented construction effort by pre-Columbian Native Americans. It has been estimated that from 2,000 to 6,000 people occupied Chaco Canyon during its heyday (Windes, 1984; Drager, 1976). One indication of Chaco's regional importance is a network of roads that linked Chaco Canyon with other great houses and communities spread throughout a region covering at least 60,000 km^2 (fig. 2). At the height of its cultural florescence in the 11th century, Chaco culture was characterized by the construction of monumental great houses (multistory, planned structures) that required millions of pieces of dressed sandstone and tens of thousands of roof beams. By 1130 A.D., Pueblo Bonito (fig. 3), one of 13 greathouses that occupied the canyon, was four stories tall and contained approximately 800 rooms (Neitzel, 2003). The size of Pueblo Bonito, its numerous large rooms, and the richness of its artifacts, which included caches of turquoise, copper bells, and finely crafted projectile points, suggest that it was a location where imported goods were amassed. Given the richness of its artifacts, some view Pueblo Bonito as having functioned primarily as an elite residence (Judge, 1989). Pueblo Bonito was occupied for at least 300 years; however, only 131 burials were found within the site, suggesting a sustained population averaging less than 100 people (Akins, 2003).

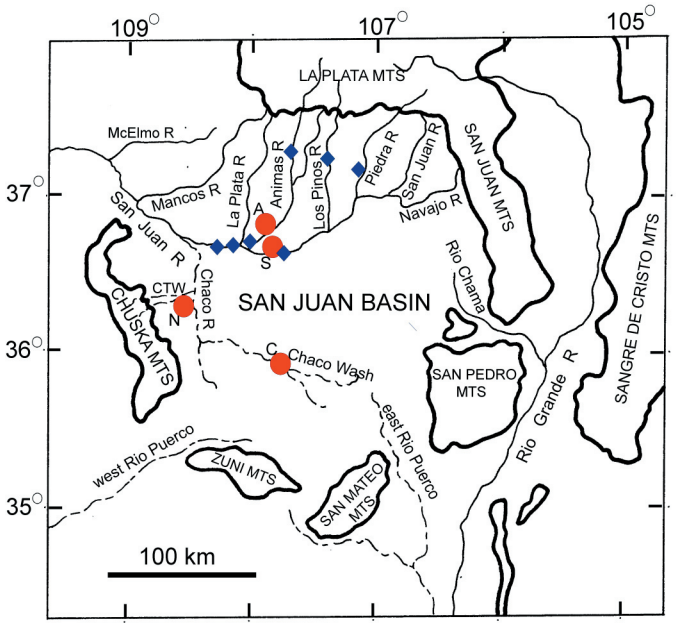

Figure 1. Site location map for the San Juan Basin. Possible sources of archeological corn are A, Aztec Ruin; S, Salmon Ruin; N, Newcomb; and C, Chaco Canyon. CTW is Captain Toms Wash. Small filled diamonds indicate sample sites along the San Juan River and its perennial tributaries. Dashed lines indicate ephemeral streams. See Figure 2 for state boundaries.

ARCHAEOLOGICAL MAIZE AND THE USE OF STRONTIUM ISOTOPES TO DETERMINE WHERE IT WAS GROWN

Maize, the mainstay of Native American diet in Chaco Canyon, was introduced to the American Southwest about 3,500 years ago. Understanding whether maize was imported into Chaco and exchanged between great houses throughout the San Juan Basin is crucial to resolving questions about whether or not food grown in the canyon was sufficient to support resident populations as well as visitors to the canyon.

This fact sheet summarizes the results of a study that determined the probable sources of archeological maize found in Pueblo Bonito ruin, Chaco Canyon, New Mexico (Benson and others, 2003). Ratios of two isotopes of strontium (^{87}Sr and ^{86}Sr) in corncobs from two great houses (Pueblo Bonito and Aztec Ruin) were compared to ^{87}Sr/^{86}Sr ratios of soil waters produced from four possible agricultural sites (Chaco Canyon, Newcomb, Aztec Ruin, and Salmon Ruin) in the San Juan Basin (fig. 1). Hereafter Aztec Ruin and Salmon Ruins will be referred to as Aztec and Salmon. The two isotopes of strontium (Sr), ^{87}Sr and ^{86}Sr, differ by only one mass unit; therefore, ratios of the two isotopes remain unchanged by physical and chemical processes. Thus, the ^{87}Sr/^{86}Sr ratio of a corncob is identical to the ^{87}Sr/^{86}Sr ratio of the soil water that sustained its growth, which in turn is identical to the ^{87}Sr/^{86}Sr ratio derived from the dissolution of soluble minerals (carbonates) in the soil zone (Benson and others, 2003).

POSSIBLE SOURCE AREAS OF ARCHEOLOGICAL MAIZE

There are four possible areas that could have supplied maize to Pueblo Bonito: Chaco Canyon, Newcomb, Aztec, and Salmon. Today, Chaco is climatically marginal for the production of maize, and paleoclimatic reconstructions demonstrate

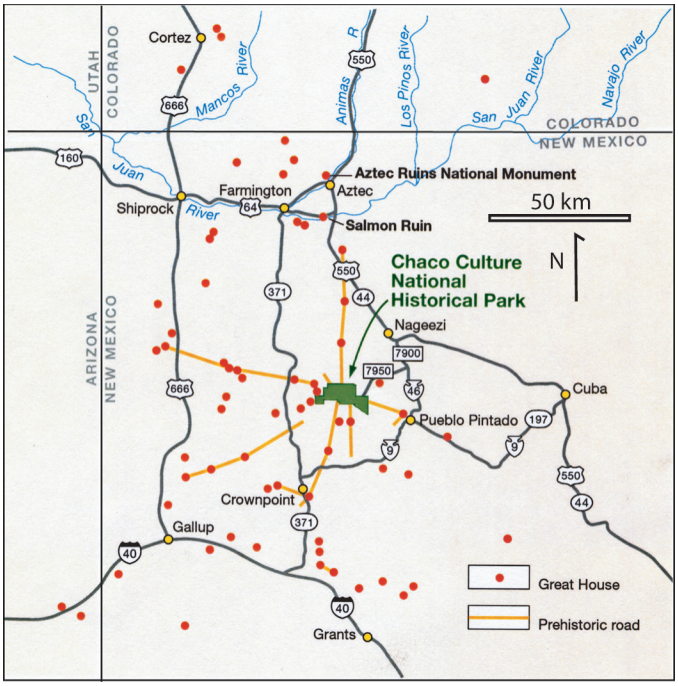

Figure 2. Prehistoric roads and great houses in the San Juan Basin.

that sustained production of maize in this area always was precarious (Toll and others, 1985). Newcomb, located at the base of the Chuska Mountains (hereafter referred to as the Chuskas), has a longer growing (frost-free) season than Chaco. Unlike the Chaco area, the Chuskas accumulate winter snow that melts and runs off during spring and early summer and flows down Captain Toms Wash (fig. 1). Both the longer growing season and the existence of a relatively reliable source of irrigation water enhance the agricultural potential of Newcomb. In addition, abundant maize was documented as having been grown here in the middle 19th century. For example, during a military expedition to Navajo country in 1849, Lt. J. H. Simpson noted "very extensive and luxuriant cornfields" in the Newcomb area (Simpson, 1852).

The other two sites (Aztec and Salmon) are located near perennial river systems that provide a reliable source of irrigation water. Aztec (fig. 4) is located on an alluvial fan adjacent to the Animas River floodplain, and Salmon (fig. 5) is situated on a low terrace adjacent to the San Juan River floodplain (fig. 1).

CONSTRUCTION HISTORIES

The construction histories of the four archeological sites indicate that exchange between the sites could have occurred during specific time intervals. Major construction episodes at Pueblo Bonito indicate that it was occupied between approximately 850 and 1150 A.D. (Windes, 2003). Numerous great houses in the Newcomb area began construction during the early 800s, and some were occupied until 1300 A.D. (Marshall and others, 1979; Fowler and Stein, 1992). Thus, exchange between Newcomb and Pueblo Bonito could have occurred during the entire time interval that Pueblo Bonito was occupied. Construction of Salmon and the immense Aztec Ruin began 220 and 260 years after the initial occupation of Pueblo Bonito (Robinson and Cameron, 1991; Stein and McKenna, 1988); therefore, exchange between Pueblo Bonito and the two northern great houses could only have occurred late in the occupation history of Pueblo Bonito.

Figure 3. Pueblo Bonito. Photo courtesy of Chaco Culture Natural History Park.

SAMPLE COLLECTION AND PROCESSING

The sampling strategy was guided by what is known or conjectured about pre-Columbian agricultural practices. In Chaco Canyon (fig. 6), it is possible that some fields were irrigated with runoff from side-canyon tributaries whose waters were diverted to field-irrigation systems located on alluvial fans (Vivian, 1990). Floodwater irrigation of crops on the Chaco Wash floodplain also may have occurred when the channel was not incised; however, this is not likely, given the high salinity of Chaco Wash water and floodplain soils.

The Newcomb area is a site where maize could have been grown on floodplain deposits, and in the Salmon and Aztec areas, maize could have been grown on both floodplain and alluvial fan deposits. Therefore, soil samples were collected from a variety of topographical features—principally alluvial fans and floodplains—by augering eolian, floodplain, and alluvial fan sediments or sampling sediment exposures on the banks of washes and arroyos.

Because stream water used for irrigation also contains Sr, samples were collected from the San Juan River drainage and its tributaries, including the ephemeral Chaco, Captain Toms, and Skunk Springs washes. The latter is a tributary to Captain Toms Wash.

$^{87}Sr/^{86}Sr$ ratios of soil waters from sediment where maize may have been grown were compared the $^{87}Sr/^{86}Sr$ ratios of archeological maize (cobs). To produce $^{87}Sr/^{86}Sr$ ratios characteristic of soil water, Sr was extracted by leaching the soil samples with a weak acid, and $^{87}Sr/^{86}Sr$ values of the simulated soil waters were obtained using isotope mass spectrometry. To ascertain the source of maize found in Pueblo Bonito, seven cobs were analyzed that were found during the excavation of the structure by George Pepper, between 1886 and 1899, as part of the Hyde Exploring Expedition (fig. 7). Ten cobs from Aztec also were studied to determine whether they possessed $^{87}Sr/^{86}Sr$ ratios similar to those in simulated soil water produced from samples of nearby alluvial fans and floodplains. Prior to mass spectrometric analyses, the cobs were ashed and dissolved in nitric acid to eliminate their organic content.

Figure 4. Aztec Ruin. Photo courtesy of Aztec Ruin National Monument, National Park Service.

Figure 5. Salmon Ruin. Photo courtesy of the San Juan County Museum Association -Salmon Ruins.

RESULTS

$^{87}Sr/^{86}Sr$ data for soil and surface waters have been plotted together with $^{87}Sr/^{86}Sr$ ratios for archeological cobs from Pueblo Bonito and Aztec (fig. 8). Comparison of the $^{87}Sr/^{86}Sr$ ratios of the Pueblo Bonito cobs with $^{87}Sr/^{86}Sr$ ratios in soil water from Newcomb and Chaco Canyon indicates that six cobs were probably grown in Newcomb area fields close to the base of the Chuskas. In particular, the $^{87}Sr/^{86}Sr$ ratios of simulated soil waters from upper parts of the Captain Toms and Skunk Springs drainages and the $^{87}Sr/^{86}Sr$ ratios of surface water from the two drainages are similar to the $^{87}Sr/^{86}Sr$ ratios of the six cobs (fig. 8).

One surface-water sample from Chaco (a sample derived from flow in Fajada Wash) has a $^{87}Sr/^{86}Sr$ ratio that falls within the $^{87}Sr/^{86}Sr$ range of the six cobs. Fajada Wash is usually a minor contributor of water (and Sr) to Chaco Wash, and the $^{87}Sr/^{86}Sr$ value of Chaco Wash water is unlike that of Pueblo Bonito cobs (fig. 8). Two simulated soil waters from Weritos Rincon and Lizard House Arroyo also have $^{87}Sr/^{86}Sr$ ratios that fall within the range of Pueblo Bonito cob $^{87}Sr/^{86}Sr$ ratios. Benson and others (2003) used soil water and cob trace-element ratios to demonstrate that these two sites could not have been the source of cobs found in Pueblo Bonito.

Pueblo Bonito cob H-10648 has a $^{87}Sr/^{86}Sr$ ratio similar to that of cobs found in Aztec and also similar to that of a soil water produced from a floodplain sample at Aztec (AZR#2) (fig. 8). Aztec cob $^{87}Sr/^{86}Sr$ ratios indicate that some of the cobs probably were grown in Aztec soils. Most of the cobs with larger $^{87}Sr/^{86}Sr$ ratios probably were grown in Salmon soils. Cobs with smaller $^{87}Sr/^{86}Sr$ ratios may have been grown in the Animas River floodplain (AR#1), using water from the Animas River for irrigation. The $^{87}Sr/^{86}Sr$ ratio of Animas River water indicates significant variability with the highest $^{87}Sr/^{86}Sr$ ratio having nearly the same value as two cobs from Aztec (fig. 8). In fact, the Animas River may have experienced higher $^{87}Sr/^{86}Sr$ ratios from time to time, depending on the relative flux of Sr from its tributaries whose $^{87}Sr/^{86}Sr$ values range from 0.7097 to 0.7099 (Benson and others, 2003).

SUMMARY

The oldest maize found in Pueblo Bonito probably was grown in an area at the base of the Chuska Mountains 80 kilometers (km) to the west. One maize sample (H-10648) found in Pueblo Bonito came from the San Juan or Animas river floodplains 90 km to the north. This study has demonstrated that maize was transported over considerable distances in pre-Columbian times.

—Larry Benson

For more information about this fact sheet and supporting files contact:

Larry Benson lbenson@usgs.gov
U.S. Geological Survey
3215 Marine Street
Boulder, CO 80303
(303) 541-3005

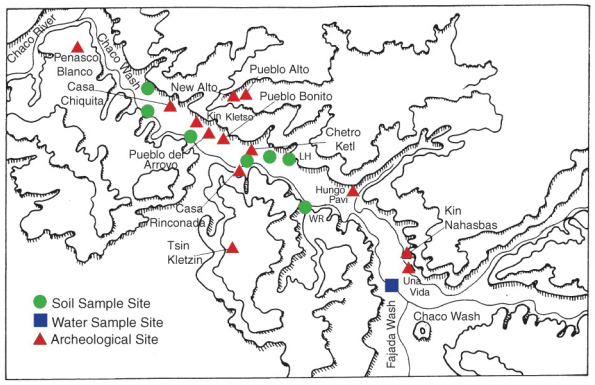

Figure 6. Soil and water sample sites in Chaco Canyon. The Lizard House Arroyo (LH) and Weritos Rincon (WR) soil sample sites are labeled. Canyon walls are hachured.

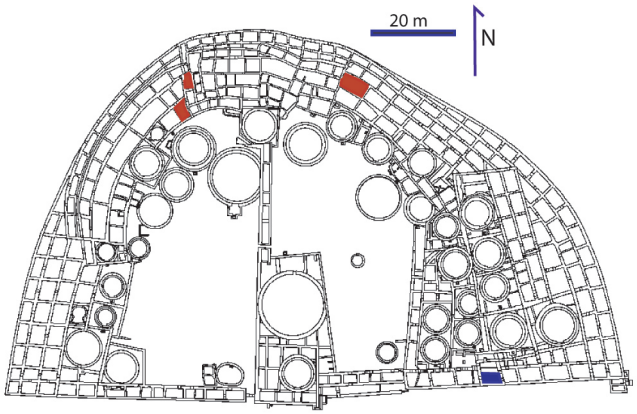

Figure 7. Areal view of room and kiva layout of Pueblo Bonito. Rooms in red are in older part of structure where cobs were found. Room in blue is in younger part of structure where cob H-10648 was found. Kivas are circular structures.

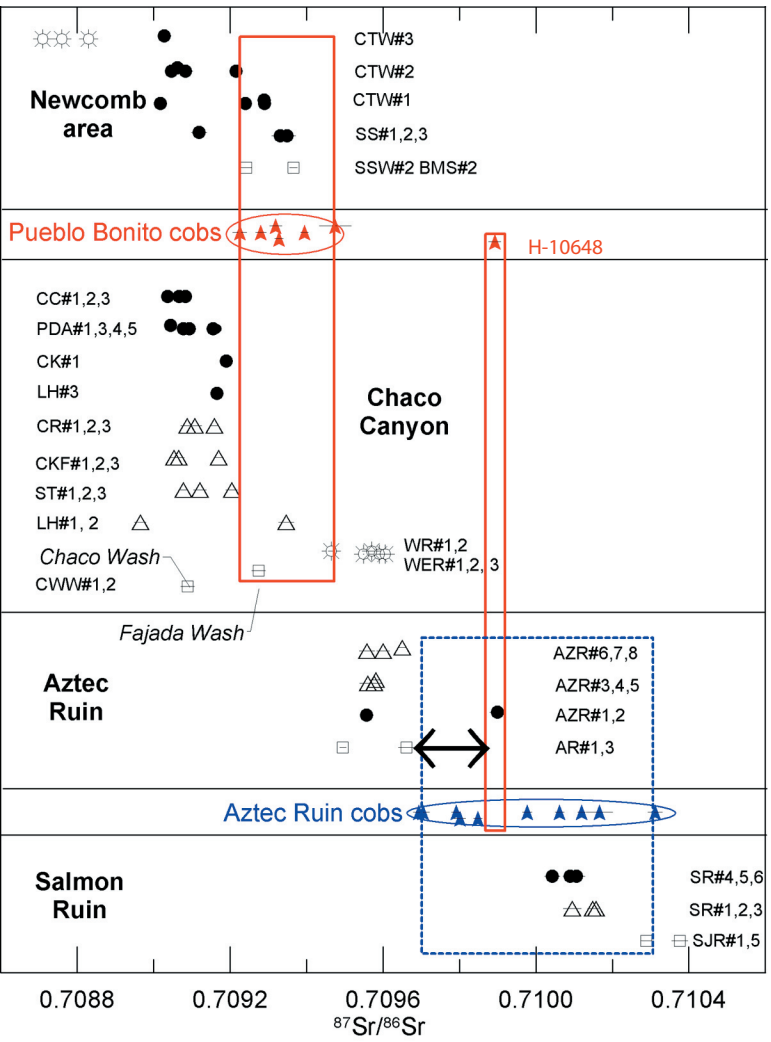

Figure 8. $^{87}Sr/^{86}Sr$ ratios of eolian (☼), floodplain (●), and alluvial fan (Δ) sediments; surface waters (□); and cobs (▲). Abbreviations: SS and SSW (Skunk Springs Wash), CTW (Captain Toms Wash), BMS (Basketmaker site on CTW), CC (Casa Chiquita), PDA (Pueblo del Arroyo), CK and CKF (Chetro Ketl Field area between LH and the Chetro Ketl Greathouse), LH (Lizard House Arroyo), CR (Casa Rinconada), ST (Section 10 site), WR and WER (Weritos Rincon), AZR (Aztec Ruin), AR (Animas River), SR (Salmon Ruin), and SJR (San Juan River). The red rectangles enclose the $^{87}Sr/^{86}Sr$ ranges of Pueblo Bonito cobs. The blue dashed rectangle encloses the $^{87}Sr/^{86}Sr$ range of Aztec Ruin cobs. $^{87}Sr/^{86}Sr$ ratios from Animas River tributaries range from 0.7097 to 0.7099 (double-headed arrow)(Benson and others., 2003).

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