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Geochemical, economic, and ethnographic approaches to the evaluation of soil, salinity, and water management in Chaco Canyon, New Mexico

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ABSTRACT

Salinity meter, powder X-ray diffraction, inductively coupled plasma atomic emission spectroscopy, and energy dispersive X-ray fluorescence spectrometry of alluvium and anthropogenic sediments demonstrates that the salinity levels of the water and soil resources used by Ancestral Puebloan people during the Bonito Phase in Chaco Canyon, New Mexico were negligible. Salinity levels were not high enough to argue that they were deleterious to farming at Chaco Canyon. The overtly high salinity levels reported by Benson cannot be replicated. Ethnographic data show that Chaco Canyon contained more than adequate sediments (perennial stream alluvium, ephemeral rincon alluvium, aeolian sand dunes) needed to support the maize-based economy of a large Ancestral Puebloan population. The occurrence of cultigens from the Chuska Slope can be explained in terms of the economic processes of production, distribution, and exchange of goods and services that originated, sustained, enhanced, or reproduced the livelihood of Ancestral Puebloans.

1. Introduction

Chaco Canyon is located within the San Juan drainage basin of northwestern New Mexico. The canyon contains a dense concentration of multistory sandstone structures (pueblos and kivas) known as Great Houses. These structures were built by Ancestral Puebloan people during the Bonito Phase between ~850 CE and 1140 (Vivian, 1990; Vivian and Hilbert, 2012; Plog, 2012; Watson, 2014). For most of Chaco Canyon's 170 years of archaeological exploration and research, it was obvious that Ancestral Puebloans lived and grew corn in Chaco Canyon. For the last 40 years, this basic component of Ancestral Puebloan life everywhere has been questioned. The massive great house buildings have been reduced to warehouse or hotels with all the necessary subsistence items, including maize, imported from afar.

Benson (2017) has argued that the high salinity levels of the soil and water resources in Chaco Canyon, New Mexico would have prevented successful farming of the valley-floor of the canyon and the nearby Chaco and Escavada wash areas, leaving them with only enough locally produced food for no more than a few hundred people. He further maintains that land suitable for agriculture was limited to side valleys in Chaco Canyon, which forced Ancestral Puebloans to engage in the extensive trade of cultigens with populations occupying the eastern footslope of the Chuska Mountain range, also known as the Chuska Slope or Chuska Valley, New Mexico.

Clearly, goods that originated from the Chuska Slope occur in archaeological contexts at Chaco Canyon (Kohler, 2001; Lekson, 2006). While I do not question whether or not cultigens from the Chuska Slope are present in Ancestral Puebloan features and middens, I will show that:

(1) the salinity levels of soil and water within many parts of Chaco Canyon were negligible and could have supported a Bonito Phase, Ancestral Puebloan maize-based economy;
(2) Chaco Canyon contains a wealth of perennial stream alluvium, ephemeral rincon alluvium, and aeolian sand dunes, which could have provided the Ancestral Puebloan people with more than enough cultivatable land to support a sizable Bonito Phase population; and,
(3) cultigens from the Chuska Slope can best be explained in terms of the Ancestral Puebloan economy, which would have included the exchange networks of Chaco Canyon residents.

Recently, Tankersley et al. (2016) analyzed the pH and mineralogical composition of more than 400 stratified sediment samples from various locations in Chaco Canyon including Chetro Ketl, Cly's Canyon, Dune Dam, Robert's Great House, Tsin Kletzin Reservoirs 1 and 2, and Weritos Rincon. Rather than relying on water quality data from the United States Geological Survey (USGS)(c.f. Benson, 2017), Tankersley et al. (2016) determined the elemental composition of water samples from Chaco

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Canyon, which included the Chaco Wash, Escavada Wash, and several tributary rincons. Powder X-ray diffraction (XRD) and inductively coupled plasma atomic emission spectroscopy (ICP-ES) analyses demonstrated that the salinity levels in both the soils and water of Chaco Canyon are suitable for growing maize in a dry land environment.

To further illustrate the capacity of the soil and water in Chaco Canyon to support the maize-based economy of a residential population during the Bonito Phase, I used energy dispersive X-ray fluorescence spectrometry (ED-XRF) as an additional and independent proxy to analyze contemporary alluvium samples from the Escavada Wash, Chaco Wash and its upper tributaries, the Fajada and Gallo washes, and adjacent rincons, and anthropogenic sediments from a Bonito Phase water-management feature in Chaco Canyon (Tankersley et al., 2017). The results of ED-XRF analysis are briefly discussed. I then posit the underlying mechanisms of an Ancestral Puebloan maize-based economy within Chaco Canyon.

2. ED-XRF

Samples of modern alluvium were collected in 2016 from natural exposures of alluvium and anthropogenic sediments. Samples were collected in 2015 from 10-cm arbitrary levels within mainly laminated, fine-textured fluvial sediments exposed in 2 1-m^3 excavations, known as Operations C-01 and C-03, adjacent to Gwinn Vivian's (1972) Chaco Canyon Water Control Project (CCWCP) canal feature A-3e (Tables 1 and 2). The Bonito Phase feature A-3e is within the site 29SJ1761. It is

Table 1
The percent composition of Na and K in sediment samples from Chaco Canyon.

Sediment source (sample)	Location (easting and northing)	Na %	K %
Rincon 1 (R1)	230186 E 3998084 N	1.04	2.21
		0.82	2.20
		1.07	2.21
Mean		0.98	2.21
Rincon 3 (R3)	230543 E 3997771 N	1.21	2.67
		1.09	2.70
		1.19	2.67
Mean		1.16	2.68
Rincon 4 (R4)	230570 E 3997462 N	0.84	2.40
		0.81	2.40
		0.71	2.39
Mean		0.79	2.40
Rincon 5 (R5)	230676 E 3997207 N	1.38	2.38
		0.89	2.38
		0.95	2.41
Mean		1.07	2.39
Fajada Wash (FW)	237185 E 3987761 N	0.82	2.48
		0.69	2.49
		0.73	2.49
Mean		0.75	2.48
Gallo Wash (GW)	241328 E 3992941 N	1.02	2.45
		0.83	2.45
		0.82	2.47
Mean		0.89	2.46
Chaco Wash (CW)	229923 E 3997376 N	1.05	2.38
		1.26	2.37
		1.01	2.37
Mean		1.10	2.37
Escavada Wash (E1)	243640 E 3996718 N	1.61	2.31
		1.57	2.29
		1.46	2.30
Mean		1.55	2.30
Escavada Wash (E2)	236391 E 3998949 N	1.52	2.32
		1.52	2.30
		1.58	2.32
Mean		1.54	2.31
Escavada Wash (E3)	233906 E 3999484s	1.62	2.27
		1.69	2.28
		1.63	2.26
Mean		1.65	2.27

Table 2
The percent composition of Na and K in anthropogenic Bonito Phase, Ancestral Puebloan sediments.

Unit stratum[a]	Na %	K %
C-03 A	0.79	1.97
	1.02	1.99
	0.62	1.97
Mean	0.81	1.98
C-03 B	Bd[b]	0.17
	Bd	0.17
	Bd	0.16
Mean	Bd	0.17
C-03 C1	1.28	1.41
	1.64	1.44
	1.17	1.41
Mean	1.36	1.42
C-03 C2	Bd	0.17
	Bd	0.17
	Bd	0.16
Mean	Bd	0.17
C-03 D	1.87	1.90
	1.53	1.88
	1.57	1.89
Mean	1.66	1.89
C-01 C4	Bd	0.16
	Bd	0.16
	Bd	0.16
Mean	Bd	0.16
C-01 C3	1.53	2.22
	1.63	2.20
	1.78	2.18
Mean	1.65	2.20
C-01 C3	1.13	2.41
	1.27	2.37
	0.95	2.36
Mean	1.12	2.38
C-01 C3	1.52	2.27
	1.30	2.27
	1.47	2.26
Mean	1.43	2.27
C-01 C1-C2	1.60	2.05
	1.12	2.07
	1.20	2.05
Mean	1.31	2.06
C01 A1	1.61	1.98
	1.38	1.97
	1.28	1.97
Mean	1.42	1.97
C-01 D	1.25	2.31
	1.25	2.29
	1.49	2.35
Mean	1.33	2.31
C-01 G	1.53	1.99
	1.38	1.97
	1.63	2.01
Mean	1.51	1.99
C-01 E	1.13	2.19
	1.19	2.20
	0.90	2.18
Mean	1.07	2.19
C-01 G	1.37	2.02
	1.45	1.99
	1.54	2.02
Mean	1.45	2.01
C-01 I	1.59	2.34
	1.26	2.37
	1.52	2.39
Mean	1.46	2.37
C-01 J	1.60	1.93
	1.21	1.91
	1.34	1.91
Mean	1.38	1.92
C-01 K	1.39	2.29
	1.48	2.29
	1.38	2.30
Mean	1.42	2.29
C-01 I	1.39	2.35
	1.48	2.34