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DISCONTINUITY IN THE FIJIAN ARCHAEOLOGICAL RECORD SUPPORTED BY A BAYESIAN RADIOCARBON MODEL

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ABSTRACT. The Fijian archaeological record is segmented into a series of phases based on distinctive transformations in ceramic forms. Interpretations of the mid-sequence (~1500–1300 cal BP) transition between the Fijian Plainware phase and the Navatu phase are contentious, with alternative explanations of population replacement versus internal processes of culture change. We present and analyze a series of Fijian Plainware and Navatu phase AMS radiocarbon dates acquired from superimposed but stratigraphically separated occupation floors at the Sigatoka Sand Dunes site on the southwest coast of Viti Levu. Employing an OxCal Bayesian sequential model, we seek to date the temporal span for each occupation as well as the interval of time occurring between occupation floors. The latter is estimated to be 0–43 calendar years at 2σ probability. The magnitude of ceramic and other differences between the Fijian Plainware and Navatu phase occupations at Sigatoka is substantive. We conclude that the abruptness of this change can be explained only by exogenous replacement at the Sigatoka site.

INTRODUCTION

Beginning ~3050 cal BP with first settlement by peoples of the Lapita cultural complex, the islands of Fiji have had continual occupation. This is modeled in the archaeological record by a series of culture historical phases defined exclusively by perceived transformations in earthenware ceramic assemblages (Green 1963; Frost 1979). How archaeologists interpret these changes, and subsequent implications for our understanding of the Fijian past, has been contentious (Marshall et al. 2000:3–8). This is particularly so for Fijian Plainware and Navatu ceramics, respectively defining sequent phases of the Fijian mid-sequence. To some (Frost 1979; Best 2002; Burley 2005, 2013), Navatu ceramics are significantly distinct and represent a break in the archaeological sequence, one possibly reflecting a foreign group of migrants into Fiji. To others (Hunt 1986; Rechtman 1992; Clark 2009), the abruptness of the transition is less than apparent, and models invoking migration rather than internal cultural processes to explain change are argued to be unsupported and insufficient.

This article addresses the question of the Fijian mid-sequence transition through analysis and Bayesian modeling of a series of Navatu and Fijian Plainware radiocarbon dates from the Sigatoka Sand Dunes site on the southwestern coast of Viti Levu, western Fiji (Figure 1). Rapid burial, and equally rapid erosion of archaeological remains in this parabolic dune field, has been recognized, and substantial research has occurred here since the 1940s (e.g. Gifford 1951; Birks 1973). Archaeological survey of the dunes by Burley (2005) in 2000 recorded a village locale at Sigatoka where Navatu and Fijian Plainware occupations are superimposed but stratigraphically separated by a layer of dune sand. Intermittent excavation at this site since 2000 provides a substantial and substantive data set to define distinctive differences between the ceramic assemblages (Burley 2005, 2013). Modeling of the chronostratigraphic context of these assemblages from associated ^{14}C dates provides new insight into the abruptness with which this transition took place. Ultimately, this study argues that the negligible time depth between occupation floors with highly distinct ceramic suites can be explained only by external replacement at Sigatoka if not elsewhere in the Fijian island group.

Context

Iron sand sediments from slope erosion in the Viti Levu highlands are deposited in the Sigatoka River and transported to the coast (Figure 1). Freshwater flow at the river mouth inhibits formation of a fringing reef, resulting in the sediment load being pushed long shore to the west, and then onto the delta shore by high surf. The long-term result has been formation of a 4.8-km-long coastal dune field with elevations of up to 60 m in some areas. In its process of formation and sand accumulation, the dunes periodically have buried archaeological remains spanning the past 2700 yr, especially in the eastern area near the river mouth. As the dune field margin erodes and moves inland today, these materials become exposed, revealing a series of "snap shots" into the Fijian past (Burley 2003).

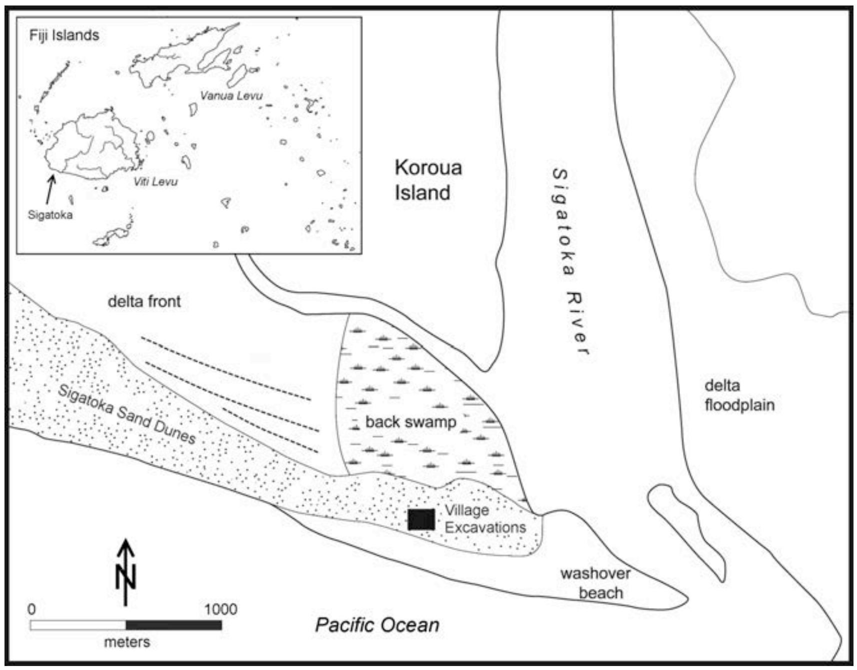

Figure 1 Sigatoka Sand Dunes, Viti Levu, Fiji. Fijian Plainware and Navatu village excavation area.

Sand dune formation has not been a continuous process. Between ~2000 and 1450 cal BP, the coastal dune front was stabilized with vegetation growth and development of an overlying soil (Dickinson et al. 1998). This attracted a small agricultural settlement to the river mouth area where individuals were engaged in the full range of village life, including burial of their dead in an organized cemetery nearby (Burley 2005). The ceramic assemblage produced by this group, as is the phase to which it associates, is referred to as Fijian Plainware. Between 1450 and 1350 yr ago, dune formation resumed, the village was abandoned, and dune sand buried the archaeological remains. Navatu phase people took up residence on top of the former village after that event, this group having a distinct and different type of ceramic assemblage. The economic rationale for this occupation was the production of sea salt using large ceramic salt trays for solar evaporation of seawater (Burley et al. 2011). Presumably in the onslaught of blowing sand, this village also was abandoned and subsequently buried.

Simon Fraser University archaeological field schools carried out excavations of the Fijian Plainware/Navatu phase village site in 2000, 2002, 2008, 2010, and 2012. These have exposed a contiguous area of 166 m^2, leading to the recovery of close to 175,000 ceramic sherds and other artifacts as well as documentation of architectural and occupation features. Site stratigraphy is consistent across this area with the exception of a variable thickness in the overlying drift sand. For example, the site was discovered in 2000 because eolian movement of the sand cover exposed the Navatu occupation surface; 2012 excavations 15 m to the east required the removal of overlying sand up to 1 m thick. Essentially, however, the stratigraphy incorporates three critical units exclusive of the drift sand cap (Figure 2). These include the Navatu phase occupation floor, a sand layer of 10 to 20 cm thickness immediately below, and the Fijian Plainware occupation floor (Figure 2). Occupation floors are well defined by dense concentrations of pottery sherds and other materials including hearth, pit, and post-hole features. Excavation methods employing small hand tools have emphasized stratigraphic provenience control throughout the various project years.

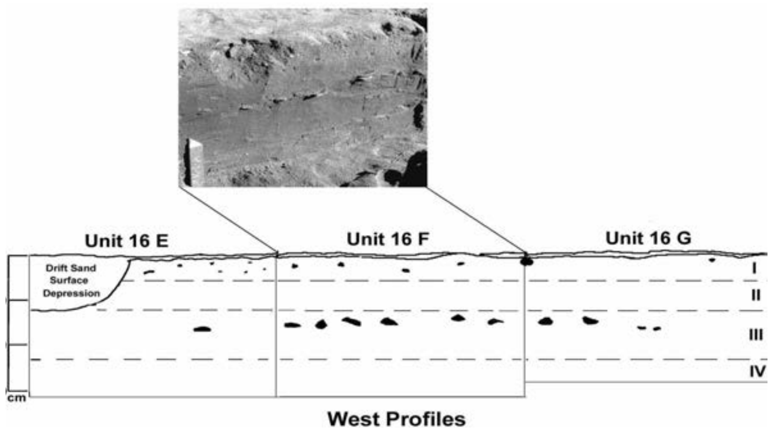

Figure 2 Stratigraphic profile for a section of the 2000 field season excavation area. Stratum I, the Navatu phase occupation floor, is on or very close to the surface in this part of the site. Stratum II is the intervening sand layer while Stratum III is the Fijian Plainware occupation floor. Ceramic sherds protruding from the section face are darkened.

Charcoal samples for ^{14}C measurement were collected in each of the excavation years. Most are concentrations of small charcoal flecks recovered *in situ* from the occupation floors, although occasional hearth features and earth ovens have provided larger concentrations of charcoal chunks. From the 2000 excavation project, seven samples were selected for AMS ^{14}C measurement at the Lawrence Livermore National Laboratory, California. Three of these are from the Navatu occupation floor and four from the Fijian Plainware occupation (Table 1). None were identified as to wood species. With the exception of one Fijian Plainware sample, ^{14}C ages appeared to have stratigraphic integrity and coherency. As subsequently reported (Burley 2005:325–6), calibration of pooled means for the Navatu and Fijian Plainware phase indicated a separation between occupation floors of "no more than a century or two, and most probably less." The exception is far too recent for either the Fijian Plainware context from which it was collected or the Navatu phase and is excluded as an outlier in earlier publications as well as here.

Since the original Sigatoka dates were published, there has been considerable emphasis and concern in Oceanic archaeology relative to chronometric hygiene for ^{14}C dates, especially where unidentified wood species are involved (Rieth et al. 2011; Wilmshurst et al. 2011). The commonplace use of Bayesian statistics and models today (Bayliss 2009; Bronk Ramsey 2009) also provides powerful tools for interpretation of calibrated results. In light of both, five additional samples from 2008 or 2010 archaeological field seasons were submitted for AMS ^{14}C measurement to the Waikato Radiocarbon Laboratory, New Zealand (Table 1).

Table 1 Navatu and Fijian Plainware ^{14}C dates. All dates are AMS measurements with 2σ calibration based on SHCal04 calibration curve (McCormac et al. 2004).

Lab #	^{14}C date	$\delta^{13}C$	2σ cal	Material	Unit	Ex Yr
Upper Phase - Navatu						
Wk 29331	1402 ± 27	–24.7	1311–1182 BP	Residue	Unit 6	2008
Wk 29332	1448 ± 27	–22.8	1351–1276 BP	Residue	Unit 1	2008
Wk 29335	1477 ± 26	–22.9	1370–1290 BP	Plant?	I/4	2010
CAMS 70090	1400 ± 40	–28.3	1330–1178 BP	Charcoal	E/15	2000
CAMS 70091	1430 ± 40	–27.2	1365–1182 BP	Charcoal	E/3	2000
CAMS 70920	1480 ± 40	–27.3	1394–1283 BP	Charcoal	F/15	2000
Lower Phase - Fijian Plainware						
Wk 29333	1449 ± 27	–27.1	1351–1276 BP	Nutshell?	J-K/1-2	2010
Wk 29334	1474 ± 26	–24.3	1368–1288 BP	Charcoal	Unit 20	2008
CAMS 68192	1540 ± 40	–26.0	1514–1299 BP	Charcoal	K/14	2000
CAMS 68191	1550 ± 40	–27.4	1515–1303 BP	Charcoal	E/14	2000
CAMS 68194	1620 ± 40	–25.5	1540–1359 BP	Charcoal	F/14	2000

RECENT RADIOCARBON DATES

The five additional samples incorporate three from the Navatu and two from the Fijian Plainware occupation floors. Two (Wk 29331, Wk 29332) are residues from Navatu Phase ceramic sherds identified by Horrocks (2011) as having starch grains most likely consistent with taro (*Alocasia macrorrhiza*/*Cyrtosperma merkusii*), breadfruit (*Artocarpus altilus*), and arrowroot (*Tacca leontopetaloides*). These, we believe, address the issue of inbuilt age, since the plant tissues being dated have a lifespan of a single growing season. Two other samples were selected for the possibility of avoiding inbuilt age. One, a Navatu Phase sample (Wk 29335), was collected from a hearth as a concentration of a granular-like material appearing to be some type of carbonized plant remains. The second (Wk 29333) was potentially, but not conclusively, identified as nutshell fragments associated with the Fijian Plainware occupation. The fifth sample (Wk 29334), an unidentified wood charcoal, was selected for its secure Fijian Plainware stratigraphic context.

The additional Navatu dates, including the two based on residue samples, clearly fall within the expected age range of the previously submitted samples (Table 1). This congruence gives us confidence that the Navatu sample group as a whole is coherent and representative of the Navatu occupation floor. The two additional Fijian Plainware dates, however, are more recent than those from 2002. In fact, if the potential nutshell sample is taken as a valid short-lived species date, the Plainware and Navatu phase occupation floors all but abut each other in time. Based on the volume and nature of excavated archaeological data, we expect the Fijian Plainware village to have a greater timespan associated with its occupation than is the case for the Navatu occupation. It is possible, then, that the variance between the 2000 Fijian Plainware dates and the more recently collected samples represent this. That is, the sample groups come from different areas of the site, and the more recent dates potentially indicate a site expansion sequence during the Fijian Plainware phase. It also is possible that the earlier dates have a degree of old-wood effect. Notably here, the absence of a fringing reef off the Sigatoka coast results in a substantial buildup of beach-strewn driftwood, a fuel source that readily could be acquired.

OXCAL, BAYESIAN MODELING, AND CHRONOSTRATIGRAPHIC INTERPRETATION

Individual ^{14}C dates are calibrated using the OxCal radiocarbon calibration program v 4.2.1 (Bronk Ramsey 2009) employing the SHCal04 Southern Hemisphere calibration curve (McCormac et al. 2004) (Table 1). OxCal further incorporates the ability to apply Bayesian models in which data parameters refine analytic capabilities and interpretations. Here, a two-phase sequential model is applied to Navatu and Fijian Plainware dates where there is a hiatus (sand layer) between the phases. The phases, thus, are treated as sequential, not contiguous (Bronk Ramsey 2009:348). The OxCal ^{14}C calibration software incorporates the prior information of stratigraphic relationships, and the super-positional orderings of calibrated ^{14}C results. This allows for precise probabilistic statements regarding the temporal relationships between archaeological phases (Bronk Ramsey 2009). Our application of this model intends to address three questions. First, what is the age range for the Fijian Plainware occupation floor at 2σ probability? Second, what is the age range for the Navatu occupation floor at 2σ probability? And third, what is the span of time elapsing between the abandonment of the Fijian Plainware village and the resettlement of the site during the Navatu phase? The latter question provides a measure of abruptness or temporal lag allowing us to assess the nature of the mid-sequence transition at Sigatoka.

Table 2 Bayesian sequential modeled dates from OxCal v 4.2.1 (Bronk Ramsey 2009). The overall model has an agreement index of 69.0. An agreement of 60.0 or higher is considered an acceptable fit. Calibrations conducted using SHCal04 (McCormac et al. 2004). The sand level duration is based on the projected temporal interval intervening between Fijian Plainware and Navatu phase ages.

Phase		Sample	cal BP	Modeled BP (95.4%)	Agreement
Fijian Plainware	Start			1433–1307	
		WK 29333	1351–1276	1364–1303	55.5
		WK 29334	1368–1288	1368–1305	91.4
		CAMS 68192	1514–1299	1389–1305	108.2
		CAMS 68191	1515–1303	1391–1305	100.5
		CAMS 68194	1540–1359	1412–1305	20.8
Fijian Plainware	End			1351–1298	
Navatu	Start			1330–1290	
		Wk 29331	1311–1182	1310–1278	104.3
		Wk 29332	1351–1276	1315–1284	139.6
		WK 29335	1370–1290	1319–1286	92.6
		CAMS 70090	1330–1178	1313–1277	123.1
		CAMS 70091	1365–1182	1315–1280	158.1
		CAMS 70920	1394–1283	1319–1285	101.3
Navatu	End			1308–1266	
Fijian Plainware	Duration interval		0–86 yr		
Sand Level	Duration interval		0–43 yr		
Navatu	Duration interval		0–36 yr		

The results of the OxCal model are in good internal agreement (Table 2, Figure 3). There is one clearly outlying calibrated result (CAMS 68194) for the Fijian Plainware phase, it having a quite low agreement index of 20.8. This sample is the earliest uncalibrated date for the lower occupation floor and, potentially, it may be explained by the old-wood effect. We left this result in our analysis, however, as this sample also coincides with the largest plateau of the SHCal04 calibration curve during our period of interest (Figure 4). The low agreement index, thus, might be an artifact of the SHCal04 calibration curve itself. A second Fijian Plainware sample (Wk 29333) also falls below the 60 threshold that is recommended for the agreement index. As this sample is close at 55.5, and it most probably dates a short-lived sample, we again leave it in the final temporal model. By inclusion of both dates, we believe our model is conservative in its final construction yet still retains an internal agreement of 69. Figure 3 provides a temporal plot for the model, illustrating range and skew of the modeled ^{14}C probabilities.

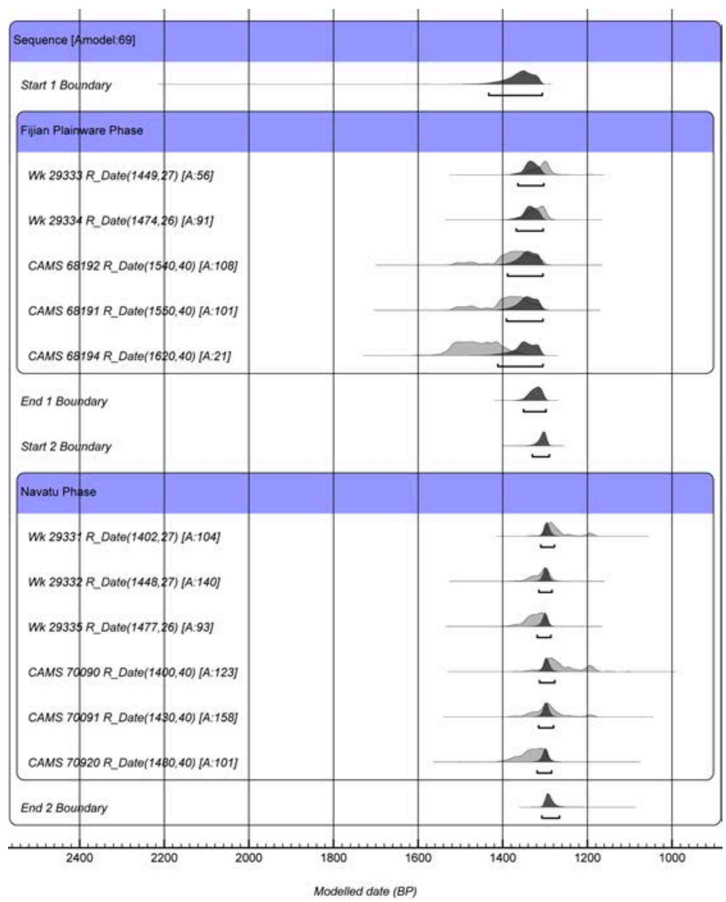

Figure 3 Calibrated 2σ date plots with modeled distributions for Fijian Plainware and Navatu phases.

Based on modeled results at 2σ (95.4%) probability, the Fijian Plainware Phase occupation floor starts between 1433 and 1307 cal BP, and ends between 1351 and 1298 cal BP (Figure 3), with a temporal span of between 0 and 86 calendar years (Figure 5). The distribution of this span is skewed towards a shorter duration. The Navatu Phase occupation floor starts between 1330 and 1290 cal BP, and ends between 1308 and 1266 cal BP (Figure 3) with a temporal span of between 0 and 36 calendar years (Figure 5). Again, the distribution of the span is skewed towards a shorter duration. The sand layer interval between the two is between 0 and 43 calendar years in duration with the skew indicative of a very short duration (Figure 5). These results are both consistent and revealing. Both Fijian Plainware and Navatu phase occupation spans are of a relatively short interval of time, but with the former being somewhat longer in duration as earlier predicted. The temporal interval between the two of 0–43 yr also represents a much shorter period than the "one to two hundred years" previously suggested (Burley 2005:325–6). The drift sand cover over the Fijian Plainware occupation floor literally could accumulate overnight. Reoccupation of the site by people of the Navatu phase, therefore, might well have been immediate. At the very least, it is clear that this replacement event at Sigatoka relative to existing models of Fijian culture history is exceptionally abrupt, quite probably occurring within the extent of a single generation.

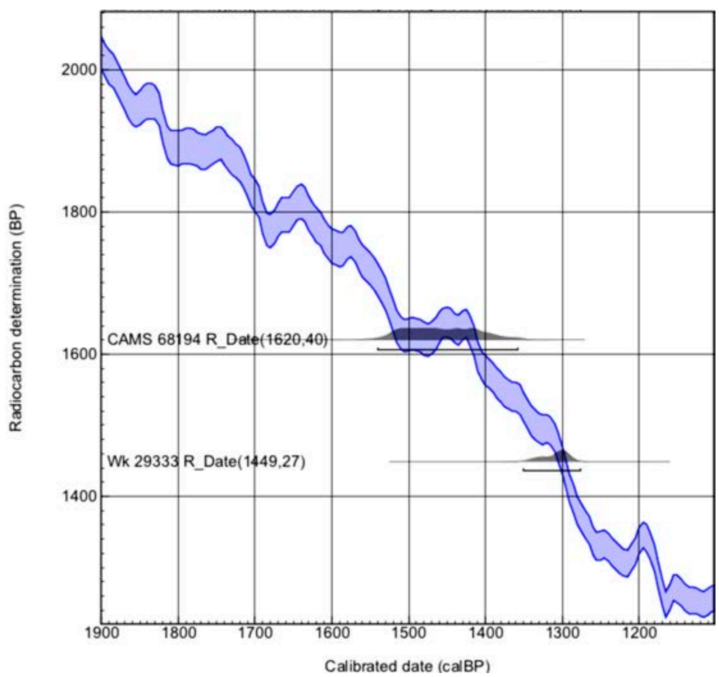

Figure 4 OxCal v 4.2.1 plot of SHCal04 calibration curve illustrating modeled dates with a less than 60 agreement index. CAMS 68914 falls on a flattened segment of the curve potentially contributing to this low agreement.

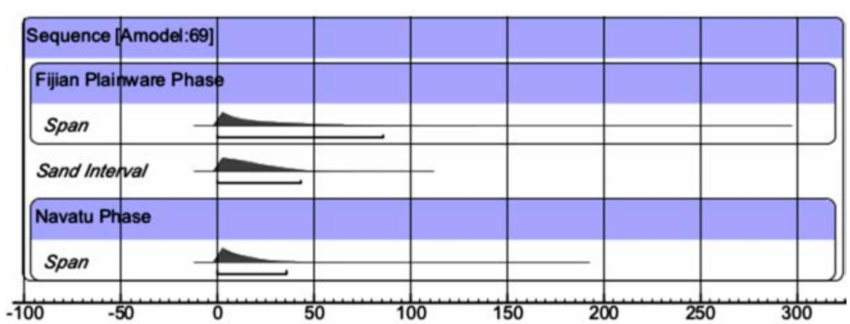

Figure 5 Sequential phase model for Fijian Plainware and Navatu phase occupation floor ^{14}C dates, Sigatoka Sand Dunes, Fiji. The 2σ predicted temporal intervals are indicated by bracketing lines beneath the plots.

IMPLICATIONS AND DISCUSSION

We have noted previously that variation between Fijian Plainware and Navatu ceramics has long been recognized. As we also state, these differences are modeled consequentially as separate and sequential phases in Fijian archaeology (Frost 1979; Marshall et al. 2000; Best 2002). The details of ceramic variation between the two assemblages at Sigatoka are described elsewhere (Burley 2005, 2013). Here, we want only to emphasize that it is not simply a transition in stylistic types, though style is a significant diagnostic. Rather, technological change occurs in ceramic temper materials, in the forming methods by which jars are produced, in the loss or addition of vessel forms, and in ceramic firing technology. Similarly, change in respective burial practices appears to have occurred in parallel fashion, while site function is dramatically varied between the two occupations (Burley 2005; Burley et al. 2011). The cumulative extent of these changes, we believe, represents a significant disjuncture in the archaeological record at Sigatoka, one where an intrusive and different population came to reside at the mouth of the Sigatoka River. That this occurred in such an abrupt fashion surely indicates population replacement on a local if not regional level.

Others have emphasized cultural/ethnic continuity in Fiji with differences resulting from the normal processes of stylistic and technological change over time and space. Clark (2009:313), for instance, attributes this change to social processes, assumed isolation, and the development of semilocalized potting styles throughout the archipelago. The Navatu ceramic suite at Sigatoka, in this scenario, would have developed gradually from Fijian Plainware ceramics elsewhere in Fiji, with the transition at Sigatoka representing expansion/replacement by an existing Fijian population. The Fijian archaeological record is not well enough understood across the archipelago to assess this argument. There are, nevertheless, two observations suggesting external rather than internal migration. First, as Best (2002:31) appropriately notes, Navatu phase ceramic traits in Fiji are not some blend of Fijian Plainware ceramics with derived stylistic types. Rather, wherever they occur, they do so “as a package, without a direct precursor.” The abruptness in the sequence at Sigatoka, thus, is replicated elsewhere. Second, as recent archaeological survey indicates, there are large parts of southern and northern Fiji where the Navatu phase seems absent, and where Fijian Plainware ceramics stylistically transition into late period forms (Burley 2010; Burley and Balenaivalu 2012; Sand et al. 1999). This patchwork distribution similarly seems indicative of an external movement of people into some, but not all parts of the archipelago.

Finally, our ability to gain a high degree of precision in chronostratigraphic context through the OxCal Bayesian model option has been insightful. This allows us the opportunity to speak of events in terms of generations rather than centuries. Recent chronological models in northwest Europe have supported the case for rapid cultural, if not genetic, replacement (Collard et al. 2010; Whittle et al 2011; Riede and Edinborough 2012). Whether or not replacement is the archaeological norm in the Southern Hemisphere is certainly debatable, nonetheless our most conservative chronological model strongly supports such a scenario in Fiji.

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