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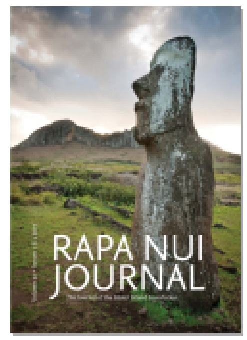

Rapa Nui Journal, Volume 32, Issues 1 & 2, 2019, pp. 1-36 (Article)

Published by University of Hawai'i Press
DOI: https://doi.org/10.1353/rnj.2019.0005

Architecturally Modified Caves on Rapa Nui: Post-European Contact Ritual Spaces?

Christopher M. Stevenson[a], Caitlin Williams[a], Everett Carpenter[a], Caitlin S. Hunt[a], and Steven W. Novak[b]

Caves on Rapa Nui that possess well-constructed tunnel entrance features are currently interpreted as places of temporary refuge (ana kionga) *used in the late seventeenth century during a period of internal island conflict. The analysis of the cave interior architecture and artifact assemblage from Site 6-357 suggests an alternate interpretation where the caves may have served as prepared ritual spaces where food consumption, sewing and body adornment were conducted. Radiocarbon and obsidian hydration dating indicate that the caves were most likely constructed after European contact and were not present at an earlier time.*

Keywords: Rapa Nui, caves, refuge, ritual

Introduction

The recent oral history of a culture can provide insights into the meaning of places on the landscape, the function of tools and structures, and the inherent qualities of material objects (Abrams 2010). When cultures exhibit great stability in cultural traditions an informant-based historical recounting may serve to interpret an archaeological record of great time depth (Kirch 2000). On the island of Rapa Nui, the brief eighteenth century visits of navigators such as Roggeveen, González, Cook, and La Pérouse (Cook 1777; Corney 1903; Beaglehole 1961; Dunmore 1994-5) and early nineteenth century visitors (e.g., Geiseler 1883; Thomson 1891; Ayres & Ayres 1995) provided numerous descriptions of dress, physique, food, material desires, architecture, and landscape features but few details on social organization, kinship, or cosmology (Richards 2008). It was only in the early twentieth century that the ethnographic research by Routledge (1919) and Métraux (1940) recorded the myths and oral history for the small, post-epidemic, population of remaining Rapanui. It is this body of data that has frequently been used to structure a cultural historical baseline for late prehistory (Mulrooney et al. 2009) and the functional, social, and symbolic interpretation of the archaeological record.

On Rapa Nui (Fig. 1), the basic assumption of cultural continuity used in the direct historical approach for the interpretation of the archaeological record has been challenged by the accidents of history. It has been argued by some scholars that the pool of cultural

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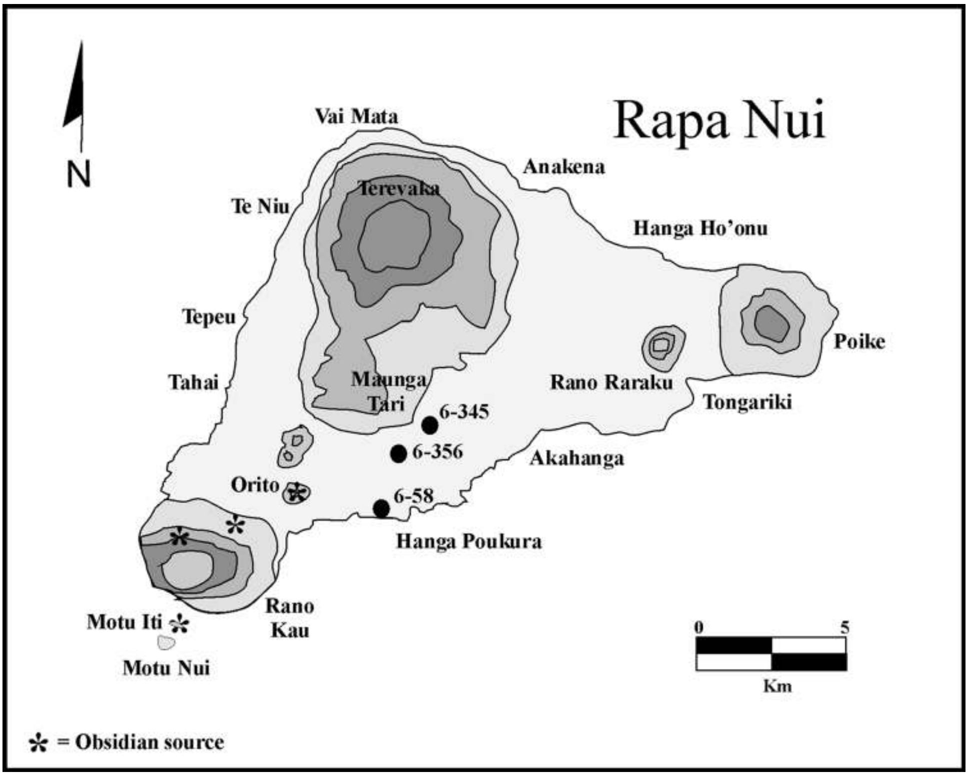

Fig. 1. Map of Rapa Nui with sites mentioned in the text.

knowledge has been diminished by a series of highly disruptive events (McCoy 1979:136; Mulrooney et al. 2009:94; Boersema 2015:144) that included slave raiding and a devastating smallpox epidemic that reduced the population in the mid-nineteenth century to 110 persons. Such a drastic series of events raises the probability that the scope and detail of cultural knowledge is just a fraction of what it once was and that new interpretations of objects, places, and events have subsequently been created by the descendants to reconstitute their world. This historical context has caused archaeologists to challenge the truth value of oral history when it does not converge with archaeological evidence (Mulrooney et al. 2009, 2010).

This predicament is very adequately illustrated in the interpretation of one type of archaeological feature referred to as the refuge cave (*ana kionga*). These small underground chambers with narrow tunnel entrances are conventionally explained as places of hiding. According to historical informants interviewed by Routledge (1919) and Métraux (1940) the locations were needed for concealment during the late seventeenth century period of conflict between competing clans. The interpretation has been used in present scholarship to support the oral history about clan relations (Kirch 2000; Flenley & Bahn 2002; Diamond 2005). This interpretation is inherently satisfying since this behavioral interpretation meshes well with the oral history, or it may in fact have been an observation central in its formulation.

In our view, there is very limited archaeological data on Rapa Nui with which to evaluate the ethnohistoric reports of modified caves as places of refuge. In this article, we present the results of excavations which challenge this interpretation. We suggest that modified caves were architecturally prepared ritual spaces for persons undergoing rites of passage, or preparing for a change in social status. One potential occupant of these caves may have been clan leaders, or their surrogates (*hopu*), or warrior contestants (*matatoa*) vying for island leadership through the annual *tangata manu* (birdman) ceremony (Routledge 1919). In this article we look at the material remains from one cave (Site 6-357) to examine the evidence for the preparation of a specialized space, the activities conducted within that space, and the time of activity occurrence.

Architecturally Modified Natural Caves

Ethnohistoric Reports and Early Observations

The observations of European navigators in the eighteenth century took note of the Rapanui domestic architecture. Although the descriptions were limited they were able to see first-hand how some of these household features were used. All of the navigators spotted the elliptical thatched hut (*hare*) that looked like an overturned boat but familiarity with other constructions (e.g., earth ovens, chicken houses) is far from comprehensive. Nonetheless, caves were noted during time ashore. Aguera (1770) mentions that some people utilized caves which required the occupant to enter feet first into a narrow entrance, but Cook's (1777) exploration party was not allowed to enter cave sites. It is the engineer of La Pérouse (1797), M. Bernizet, that first drafts a site plan with a stone-walled house, earth oven, and cave; the latter of which is rendered in top plan and cross-section. Unlike the observation of Aguera (1770), there is no doubt the structure is a subterranean chamber with a narrow tunnel entrance, which he reports to be used as a storage facility for tools and personal possessions. At the turn of the nineteenth century, the Rapanui become hostile to European shore landings (Boersema 2015) and there are no additional reports. Bartering for food and trade goods occurs on the open water (Richards 2008).

Visitors to Rapa Nui in the middle and late nineteenth century take fewer notes about the domestic settlement pattern since the focus of these visits is generally on the ceremonial center of ʻOrongo or the statue quarry at Rano Raraku (e.g., Palmer 1870; Thomson 1891). The lengthy observations by Geiseler in 1883 (Ayres & Ayres 1995) cover many domestic features but do not mention underground dwellings. Only later in the early twentieth century does Routledge (1919) gather further information on caves with tunnel entrances. In one investigation of a cave, she reports a subfloor "chamber walled and roofed with slabs, which the natives say had been used as a place of hiding in cannibal days" (Routledge 1919:272). She reports that the soil deposits within the chamber tended to be of little depth but contained spear points (*matā*), bone needles, and discarded sea shells.

The last data we have on the use of *ana kionga* comes from the cultural anthropologist Alfred Métraux. He reports that the "original purpose is unknown to the modern natives, who describe them as places of refuge in which women and children shut themselves up in times of war" (1957:75). He makes note of five of these caves, also known as *hare-kionga*, encountered during his field excursions and describes a well-known and elaborate structure of this type located behind Ahu Vai Mata where:

> Its existence is revealed by a low mound paved with boulders. A shaft 2 meters deep and lined with stones joins a horizontal passage, also flagged with carefully dressed stone, which is so low that one must crawl through it. The chamber to which it leads is oval and about 2.5 meters high. One side is natural rock and the other is faced with carefully laid stones. A platform at

> the back probably served as a bed. In this cave, as in many others, we found skeletons. (Métraux 1940:193; cf. McCoy 1976)

Métraux's behavioral assessment of cave use for refuge is, however, uncertain, as he states: "This interpretation must be treated with reserve, to say the least of it: How could these cellars with unconcealed entrances have afforded safe hiding places?" (Métraux 1957:75). Routledge (1919:272) is even less definitive about the function of a subfloor cellar found below the floor of a cave and simply reports its interpretation by the Rapanui as a place of hiding without further assessment. Thus, we cannot solely attribute the interpretation of modified caves to Métraux, as he expresses reluctance to accept the information at face value from his informants and Routledge does not have much to say about the matter. However, these early works seem to have planted a seed which later scholars have nourished.

Archaeological Evidence

Large-scale regional surveys by McCoy (1976) and Stevenson and Haoa (2008) have documented the location of numerous *ana kionga*. In McCoy's survey of the southwestern corner of Rapa Nui (Quadrangles 1, 2, 4, 5, 6), rockshelters had a very frequent occurrence ($N = 346$) but *ana kionga* only accounted for thirteen archaeological features (3.8%) within this category that included caves, overhangs, and niches. A slightly higher frequency is present within the Hanga Ho'onu region on the north coast, where 17 *ana kionga*, or 18.3%, were recorded for this feature category.

The available survey data for the Hanga Ho'onu region (Stevenson & Haoa 2008) shows that many of the *ana kionga* are part of larger site complexes that consist of domestic houses, earth ovens, walled gardens, and chicken houses that are spatially clustered within about a 30 m radius. As such, it is assumed that the *ana kionga* were actively used at the same time as the other features within the domestic cluster. In about a third of the cases, the *ana kionga* appear to be isolated cultural features. Investigators entering into these features to take internal dimensions made note of the fact that two of the caves contained fragmentary human remains.

On the offshore islet of Motu Nui, where the annual *tangata manu* (birdman) competition was played out, numerous caves are present. They have been periodically visited and partially described over the last century (Routledge 1919; Lavachery 1939; Englert 1948; Heyerdahl & Ferdon 1961). A comprehensive survey of the islet was completed by McCoy (1978) who identified 20 caves, eight of which had masonry-walled entranceways, and three of this latter category exhibited slab roofing over the tunnel entrance; a feature similar to main island *ana kionga*. Petroglyphs of *makemake*, frigate birds, vulva, and abstract forms were numerous in both modified and unmodified caves (Lee 1992; Steiner 2018).

From this point on we will refer to this type of feature as an architecturally modified cave (AMC), and not an *ana kionga*, since the activities associated with the use of the cave in prehistory have not been adequately documented or validated by a recorded event. Retention of the original nomenclature within this discussion is not compatible with the task of assessing the interpretations made by previous scholars.

Caves as Ritual Spaces

Cave archaeology on Rapa Nui was pioneered by Smith (1961) and then at a more intensive level by William Ayres in the 1970s (Ayres 1975). Stratigraphic deposits on the open landscape are rare, but small caves and rockshelters often have coherent stratigraphy containing faunal, marine, and stone tool remains. Initial excavation of these caves by Ayres was conducted to address research questions about changing subsistence adaptations (Ayres 1986; Ayres et al. 2000) and these studies have identified a shift to near-shore marine resources during the late prehistoric and post-European contact periods (Ayres 1981). This processual systems-based perspective has also limited the range of potential activities that are thought to have occurred in caves and the interpretation of AMC as places of refuge fits comfortably within this functionalist paradigm. The evidence for this interpretation is the massive, strongly constructed, and narrow access tunnel of the cave entrance and its sometimes obscure position on the terrain. It is thus thought of as a defensible position for a short-term raiding type of warfare.

The narrow access tunnels of AMC ensure that the interiors are essentially dark except for some low intensity reflected light at the doorway. As such, air circulation is poor and the interior is damp and cool (20.4 °C; 68.7° F). The basalt cap of the cave can be porous and the result is droplets of water falling from the ceiling. All of these factors make dark caves less desirable for habitation except under extreme conditions (Moyes 2012:6). Although, it should be noted that Rapa Nui houses have dark interiors and low entrances that require a person to enter on their knees.

While the darkness and small size of the cave may restrict long-term daily habitation, it can favor human interaction with the supernatural in an isolated private space away from public view. Caves can be places of liminality where the person who enters experiences new odors, temperature, variation in light, and surface textures; all of which are factors that require a person to readjust to their surroundings and focus their attention on the task at hand (Renfrew 1985; Thompkins 2012:67). Here, within a context different from daily life, people may conduct religious rituals to communicate with deities in order to affect a future outcome of an important event or social relationship. These activities may include unique paraphernalia for the preparation of offerings, specialized consumption, “killed” or broken artifacts, and painted iconography on the cave walls (Skeates 2012). On Rapa Nui, the recognition of ritual activities is much more difficult away from religious centers (*ahu*) since recognized formal votive offerings such as vessels or figurines have not been identified.

If refuge is an unsatisfactory behavioral interpretation for AMC, then how do we recognize the alternatives that may include ritual preparation? It is our hypothesis that the occupants of the cave may have been contestants in the annual *tangata manu* ceremony to determine political leadership of the island, but how can we link the activities conducted in AMC with these players? There is currently no direct physical evidence that links the ‘Orongo Birdman Cult ritual complex on top of Rano Kau (Fig. 1) with the cave deposits; and we are hard pressed to identify what that direct material link would be. Therefore, the task is to identify what ritualistic behavior might look like in the absence of formal ritual paraphernalia.

Our approach to the identification of ritual and its meaning comes from the analysis of context where the frequency of occurrence, variety, and association of different materials may provide clues about symbols and their meaning (Appleby & Miracle 2012). In the absence of elaborate ritual paraphernalia made from exotic or unusual materials, we can anticipate that rituals were conducted by using ordinary materials in different ways from normal daily life on the open landscape. The actions underground would have been performative and repetitive with the intent of reinforcing a group value or ideology (Stone 2012:366) and religious rituals would make reference to a specific deity or its physical manifestation in the secular world. The actors in these rituals may also prepare themselves for the performance through body decoration with pigments or tattoo rituals to highlight the differences from everyday life. Thus, we can expect to find a more limited diversity of activities within the AMC that are conducted in the same way over time and where the materials used and discarded represent this focus.

The Architecturally Modified Cave (Site 6-357)

Site 6-357 represents an architecturally modified cave and *tangata manu* petroglyph recorded by Patrick McCoy in his pedestrian survey of Quadrangle 6 (McCoy 1976) located on the southern coastal plain of Rapa Nui (Fig. 1). The cave consists of a cavity located under the surface of a basalt outcrop that is part of a feature complex consisting of a small house foundation (6-356a), a destroyed chicken house (*hare moa*) (6-356b), a subterranean garden (*manavai*) (6-356c), and three earth ovens (*umu*) (6-356d–f) that are surrounded by a charcoal rich cooking midden (Fig. 2). Site 6-356a–f was investigated by the lead author in 1987. The site surface surrounding the architectural features was mapped, artifacts were surface collected, and a set of fifty-six 1 m^2 test units systematically covered the area at 10 m intervals (Stevenson 1988). Site 6-357 was also excavated during this field season. The faunal assemblage from the cave was analyzed by Rorrer (1997, 1998) and Dano (1992). Church and Ellis (1996) conducted high-magnification use-wear on a sample of the obsidian assemblage.

The AMC is accessed by a small opening approximately 50 cm square. The entrance consists of a 4 m tunnel represented by a parallel alignment of stones that support the large cap stones (Fig. 3). The floor of the entrance tunnel is also paved with basalt slabs. The interior of the AMC is approximately 4 m wide, 8 m in length, and 1.5 m high near the center. The roof of the cave slopes to the edges where it meets the floor. At each end of the cave, very small natural tunnels were present, but they did not look humanly accessible and they were not investigated.

The interior of the cave shows evidence of extensive alteration from its original natural form as a volcanic gas bubble. Just inside the entrance rounded stones and shaped stones

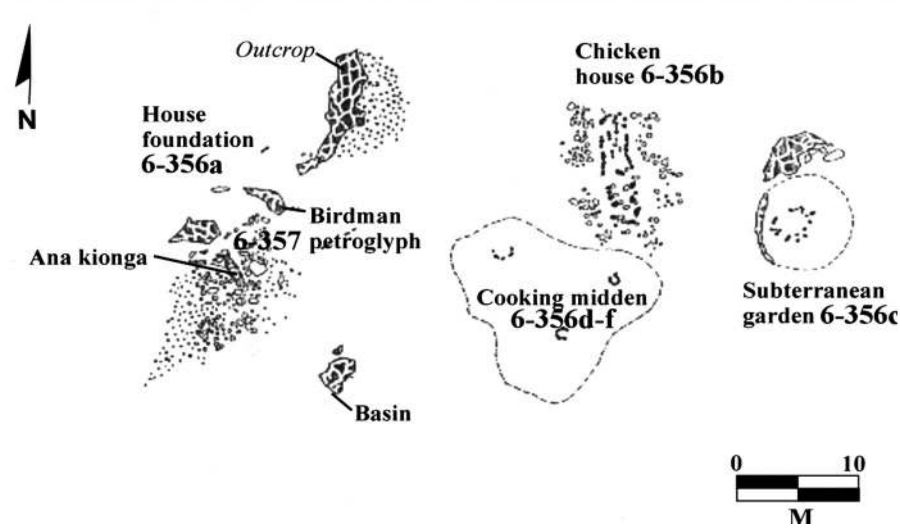

Fig. 2. Map of Site 6-356a–f and 6-357 with component features.

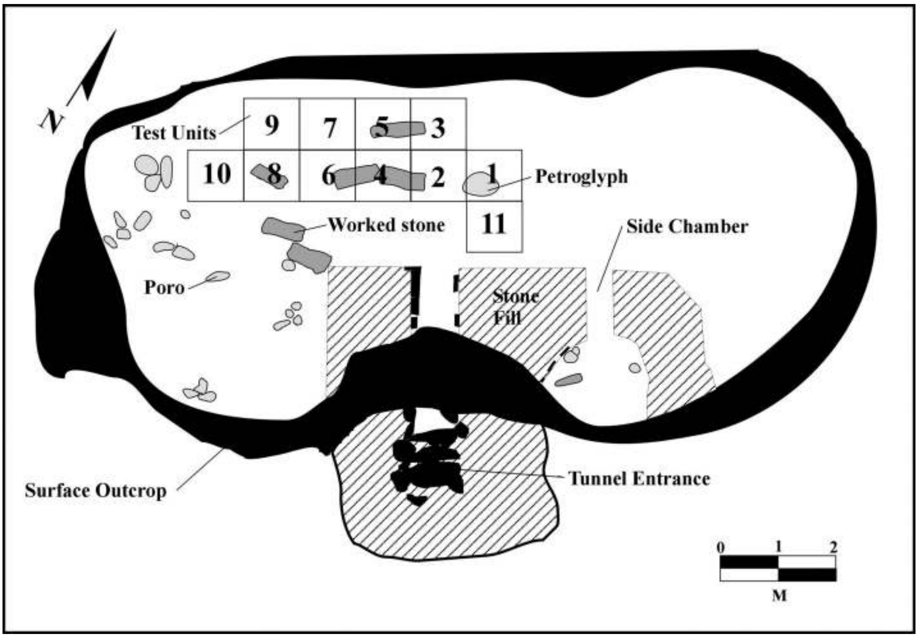

Fig. 3. Top plan of Site 6-357 showing the tunnel entrance and interior features.

(*paenga*) form a short wall that serves to lengthen the outer tunnel entrance. These stones also form a thick interior wall that has been erected to create a small side chamber to the right of the opening (Fig. 3). The ancillary room is approximately 1.5 m in diameter. Scattered on the floor of the cave were six large rectangular *paenga* that may have once formed a platform, and on the western end there was a concentration of small stones and larger rounded beach stones (*poro*) that may have formed a small pavement. A petroglyph of a sailboat (Fig. 4a) created by incision on a sea cobble is near the entrance tunnel (Fig. 3). A petroglyph of a *tangata manu* (Fig. 4b) is pecked into the surface of a basalt outcrop located 6 m to the north of the entrance (Fig. 2).

Excavation Methods

Eleven 1 m by 1 m square units were placed within the central portion of the cave in front of the tunnel entrance (Fig. 3). Test units revealed an upper 3 cm to 4 cm layer of dense, moist, and compact brown clay soil underlain by a loose and dry stratum of reddish-brown scoria. The soil layer was very rich in artifacts, but at the interface with the scoria the artifact count abruptly declined to zero. No cultural material was recovered from the scoria layer, which was excavated to a depth of 70 cm in Test Unit 1 before termination. All of the remaining test units were hand troweled to the scoria interface and the artifacts assigned to a single level (Level 1). Due to the low-light conditions, the microstratigraphy of the floor deposit was not identified at this time. Artifacts found on, or imbedded into, the surface of the cave deposit were included within Level 1.

The soil stratum within the cave was a compact clay floor containing abundant quantities of bone and lesser amounts of obsidian. The floor layer could be readily peeled from the underlying scoria. In cross-section, the soil exhibited well-defined microstratigraphy with restricted areas of compressed carbon and scattered red pigment. Because of the compact

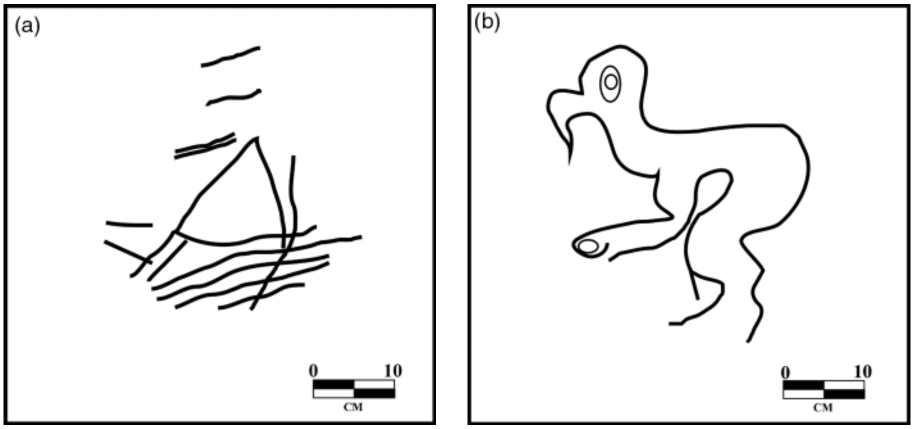

Fig. 4. Petroglyphs at Site 6-357 consisting of (a) a sailboat from inside the cave and (b) a Birdman holding an egg located on a surface basalt outcrop.

nature of the soil, the strata or the carbonized remains could not be removed as a unit. The soil from each test unit was removed from the cave and placed in a ¼ inch mesh screen. The soil was sieved and hand inspected for artifact material but not all of the clay soil passed through the sieve. Unfortunately, water flotation could not be implemented and many small ecofacts such as carbonized plant material were not fully recovered.

Three test units were placed outside of the cave in the immediate proximity of the entrance. These units demonstrated that portions of the cave exterior had been covered by about 30 cm of soil and basalt fragments that capped the original soil surface. In test units located to the east of the outcrop, an upper strata of scoria was encountered. In conjunction with the observed abrupt discontinuity between the thin soil horizon and underlying scoria within the cave, this information suggested that the cave was an artificially enlarged natural feature. The original cave was probably a small cavity that was manually enlarged through excavation in order to create a larger and level floor surface. The scoria from the cave was subsequently removed and deposited outside and around the basalt outcrop.

The large quantity of food remains from the cave floor indicates that food consumption was important. The densest cluster of faunal material from our excavation was located in front of the cave entrance. Bones of rat, chicken, and fish were recovered throughout the soil layer. Mixed in with the food remains were fragmentary and whole bone needles. The needles exhibited a heavy polish from use and were made primarily from bird bone. Manufacturing debris, consisting of long splinters of chicken femurs, was also recovered (Rorrer 1997). These data indicate that food consumption, sewing, and needle manufacture/maintenance were some of the activities conducted within the confines of the cave. We look at these and other recovered materials in greater detail below.

Archaeological Chronology

Radiocarbon Dating

Four samples were submitted for age determination by accelerator mass spectrometry to Beta Analytic, Coral Gables, Florida, or the radiocarbon laboratory at the University of Georgia (Table 1). All of the samples originated from within the floor.

Table 1. Radiocarbon age determinations for Site 6-357 (n/a = not applicable to annual species).

Provenience	Context	Material	Lab No.	Uncal. Date	δ^{13}C‰	Cal. Date 2 Sigma	Probability
TU 4, L. 1	Floor	Chicken bone (femur)	Beta-337739	580 ± 30	−12.3	1324–1343	0.0822
						1389–1440	0.9177
TU 6, L. 1	Floor	Chicken bone (femur)	Beta-333740	200 ± 30	−17.3	1654–1712	0.2478
						1718–1813	0.5391
						1835–1890	0.1346
TU 3, L. 1	Floor	Charcoal (grass stem)	UGa-37491	170 ± 20	n/a	1655–1692	0.186
						1728–1785	0.505
						1793–1812	0.112
						1919–1950	0.197
TU 3, L. 1	Floor	Charcoal (grass stem)	UGa-37492	170 ± 20	n/a	1655–1692	0.186
						1728–1785	0.505
						1793–1812	0.112
						1919–1950	0.197

Two chicken femur fragments were initially submitted and returned uncalibrated age determinations of 580 ± 30 B.P. (Beta-337739) and 200 ± 30 B.P. (Beta-333740). These results were calibrated (2-sigma) to A.D. 1324–1440 and A.D. 1654–1890, respectively. This difference in age determination of several centuries from a floor context, interpreted to be a series of short-term living surfaces, prompted a second submission of two grass stem fragments. These samples (UGa-37491, UGa-37492) returned identical age determinations of A.D. 170 ± 20 B.P. that were calibrated at 2-sigma to A.D. 1655–1950. The highest probabilities of occurrence associated with these two dates placed the occupation of the cave between A.D. 1728 and A.D. 1785; a date range that converged with the AMS determination on the one chicken femur of A.D. 1718–1813.

The reason for the earlier and non-conforming date on the second chicken femur (Beta 337739) is not completely clear. It is possible that some chickens may have been fed fish scraps or shell grit as part of their daily diet and ingested old carbon contained within these marine organisms. δ^{13}C‰ values for chicken (*Gallus gallus*) bone with terrestrial diets falls within the δ^{13}C‰ value range of 19–21‰ (Storey et al. 2013). The fact that both bones have δ^{13}C‰ values below this level suggests a marine contribution. The sample from TU 4, L.1 with a ^{14}C age of 580 ± 30 (Beta-337739) and a δ^{13}C‰ value of −12.3‰ is likely indicative of a significant marine contribution and as a result this age determination is too old in time and will not be considered further.

Obsidian Hydration Dating

Obsidian hydration dating (OHD) has been frequently applied to archaeological sites on Rapa Nui and age estimates have converged with independent radiocarbon dates (Stevenson 2000; Robinson & Stevenson 2017). In this application to 29 specimens from Site 6-357 the Arrhenius constants (*A*, *E*) have been estimated and the high temperature laboratory developed rate constant extrapolated to ambient temperature and humidity conditions using the equation:

$$K = A \exp \frac{E}{RT}, \tag{1}$$

where K is the archaeological hydration rate in μm^2/1000 years, A is the pre-exponential in the same units, E is the activation energy (J/mol), R is the universal gas constant (J/mol), and T is the temperature in Kelvin. A and E were experimentally determined in the laboratory for the Orito obsidian source at elevated temperature (140–180 °C) by Stevenson and Williams (2018). The samples in this experiment were measured by infrared photoacoustic spectroscopy to arrive at an activation energy value of 86,401 J/mol[1] and a pre-exponential. However, the final hydration rate was estimated from a generalized prediction equation (Stevenson et al. 1998) because the archaeological samples were measured by optical microscopy before the advent of infrared methods.

In order to establish an improved empirical grounding for the Orito hydration rate, we have developed an experimentally established value for the pre-exponential in micrometers (μm), rather than infrared intensity units that can be applied to older optical measurements. To achieve this, the 30 day, 160 °C experimental sample (RBC-601) was thin-sectioned and optically measured at 600× under polarized light using a video image of the hydrated surface (Fig. 5) collected with a 2MB digital camera. Image-J software was used to calculate the number of pixels (Fig. 6) and limits of the hydration layer were determined by the sharp slope inflections. Each pixel represented 0.19 μm, a value calculated from the measurement of a 70 μm calibration slide at the same magnification. The width of the hydration layer was determined to be 6.57 ± 0.19 μm.

In order to confirm this hydration layer thickness, we performed a hydrogen depth-profile analysis of the same specimen (RBC-601) by secondary ion mass spectrometry (SIMS). SIMS hydrogen profiles are collected by rastering the glass surface with cesium (Cs) ions in order to generate secondary hydrogen ions at increasingly greater depths. These are collected and sorted by a mass spectrometer to determine their concentration with increasing depth. The methods of analysis for obsidian have been well developed and documented in Novak and Stevenson (2012) and Ambrose and Novak (2012). With this as a foundation, the hydration depth profile for the 160 °C, 30 day, sample was determined to be 6.79 μm (Fig. 7) at the full-with half-maximum point. The error associated with SIMS depth profiles are approximately 0.1 μm depending upon surface roughness. These depth measurements using both optical and SIMS analysis are within experimental error. Therefore, we will use the optically derived pre-exponential value of 1.44 μm^2/day at 160 °C in our obsidian hydration date calculations to maintain methodological equivalency between the laboratory and archaeological samples.

X-ray fluorescence analysis was not conducted to determine obsidian artifact geological provenance through elemental analysis (e.g., Mulrooney et al. 2014). In its place, glass density determination was conducted on each artifact to estimate the structural water content since this parameter is the most influential determinant of the hydration rate (Stevenson et al. 1998; Stevenson & Novak 2011). Recent structural water content analysis of the artifacts from each of the four Rapa Nui geological outcrops (Orito, Motu Iti, Rano Kau I, Rano Kau II) has shown that the structural hydroxyl content for each location is 0.10% with a standard deviation of 0.005% or less (Stevenson et al. 2018). Thus, all Rapa Nui obsidian, regardless of source, will hydrate at the same rate at a specified temperature.

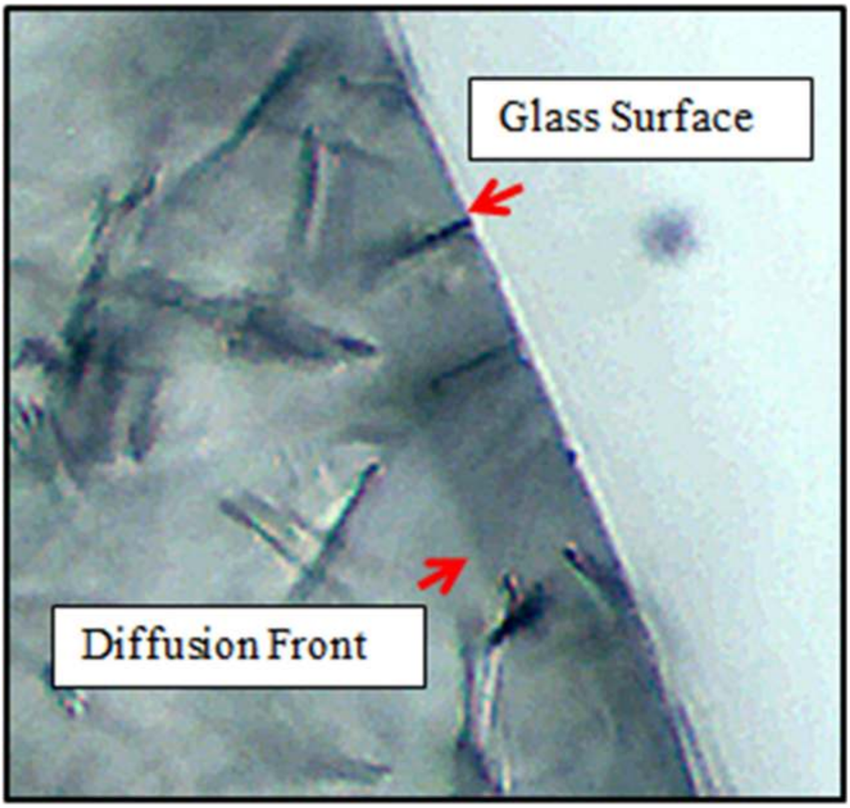

Fig. 5. Optical image of an induced hydration layer on Orito obsidian; 160 °C for 30 days.

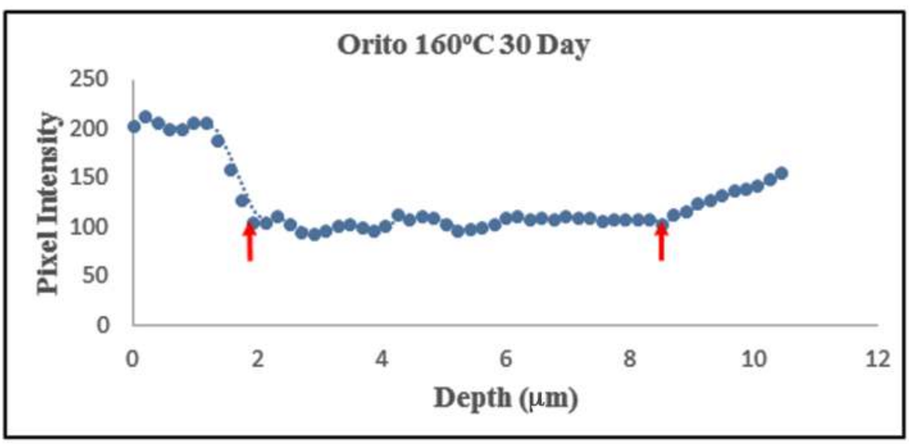

Fig. 6. Hydration layer pixel profile of Orito obsidian hydrated at 160 °C for 30 days. Width of the layer is 6.57 μm and is marked by the arrows. One pixel equals 0.19 μm.

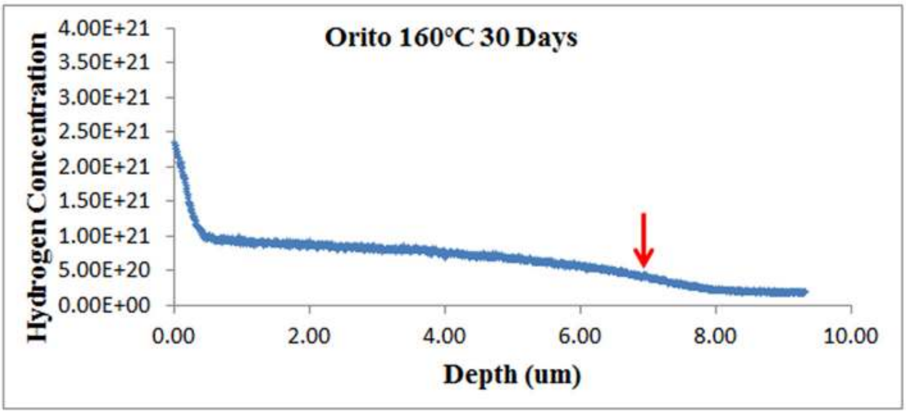

Fig. 7. SIMS hydrogen profile of Orito obsidian hydrated at 160 °C for 30 days. The full-width half-maximum point indicated by the arrow represents the diffusion front boundary.

The obsidian structural water content was determined using the Archimedes immersion method (Stevenson et al. 2018) to ensure the compositional uniformity of the obsidian artifacts with respect to this rate controlling parameter (Stevenson & Novak 2011). Soil temperature and relative humidity values for the cave were empirically determined. In 1988, a pair of desiccant based thermal cells (Ambrose 1984), were installed within the AMC. They were placed on the surface of the floor at the end of the entrance tunnel and covered with a rock. At this location no indirect sunlight fell upon the cell location. At the end of one year, the cells were removed and an effective hydration temperature of 20.4 °C and a relative humidity of 98% were determined (Stevenson et al. 1993). These parameters were used to calculate an archaeological hydration rate with the Arrhenius equation, which was used to convert the optically measured hydration rim widths into absolute

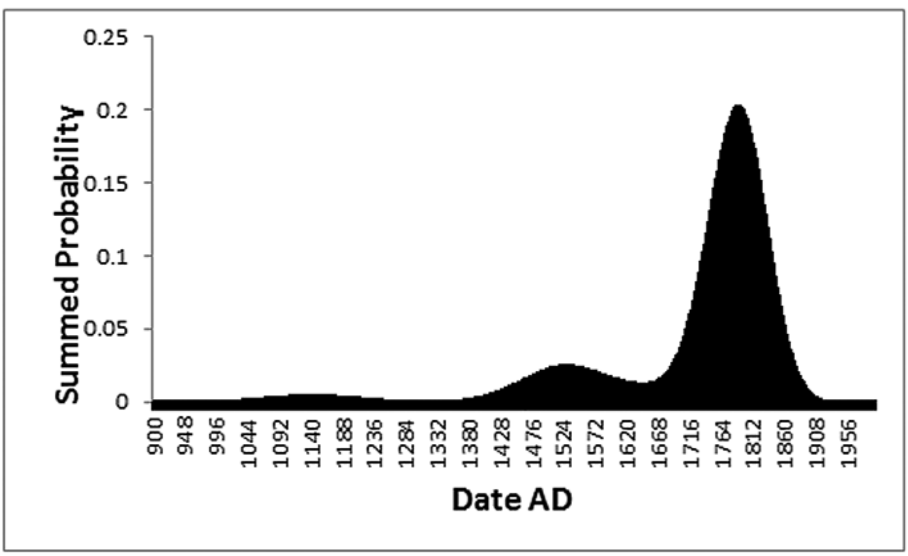

Fig. 8. Summed probability distribution for the obsidian hydration dates from Site 6-357.

Table 2. Obsidian hydration dates for Site 6-357.

Lab No.	Provenience	Rim (μm)	EHT (°C)	%RH/100	*A* (μm^2/day @160 °C)	*E* (J/mol)	Rate (μm^2/1000 years)	A.D. Date	S.D. (years)
88-419	TU 4, L. 1	1.40	20.4	0.98	1.44	86,401	5.72	1645	51
88-420	TU 3, L. 1	1.01	20.4	0.98	1.44	86,401	5.72	1810	37
88-421	TU 4, L. 1	1.04	20.4	0.98	1.44	86,401	5.72	1799	38
88-422	TU 4, L. 1	1.13	20.4	0.98	1.44	86,401	5.72	1765	41
88-423	TU 4, L. 1	2.20	20.4	0.98	1.44	86,401	5.72	1142	79
88-424	TU 3, L. 1	1.16	20.4	0.98	1.44	86,401	5.72	1753	42
88-425	TU 3, L. 1	1.12	20.4	0.98	1.44	86,401	5.72	1769	41
88-426	TU 4, L. 1	1.04	20.4	0.98	1.44	86,401	5.72	1799	38
88-427	TU 4, L. 1	1.09	20.4	0.98	1.44	86,401	5.72	1780	40
88-428	TU 4, L. 1	1.16	20.4	0.98	1.44	86,401	5.72	1753	42
88-429	TU 4, L. 1	1.61	20.4	0.98	1.44	86,401	5.72	1535	58
88-430	TU 4, L. 1	1.09	20.4	0.98	1.44	86,401	5.72	1780	40
88-431	TU 4, L. 1	1.62	20.4	0.98	1.44	86,401	5.72	1529	58
88-432	TU 4, L. 1	1.71	20.4	0.98	1.44	86,401	5.72	1477	62
88-433	TU 4, L. 1	1.13	20.4	0.98	1.44	86,401	5.72	1765	41
88-434	TU 4, L. 1	1.13	20.4	0.98	1.44	86,401	5.72	1765	41
88-435	TU 4, L. 1	1.08	20.4	0.98	1.44	86,401	5.72	1784	40
88-436	TU 4, L. 1	1.04	20.4	0.98	1.44	86,401	5.72	1799	38
88-437	TU 4, L. 1	1.60	20.4	0.98	1.44	86,401	5.72	1540	58
88-438	TU 4, L. 1	1.02	20.4	0.98	1.44	86,401	5.72	1806	37
88-439	TU 4, L. 1	0.99	20.4	0.98	1.44	86,401	5.72	1817	36
88-440	TU 4, L. 1	1.02	20.4	0.98	1.44	86,401	5.72	1806	37
88-441	TU 4, L. 1	1.09	20.4	0.98	1.44	86,401	5.72	1780	40
88-442	TU 4, L. 1	1.06	20.4	0.98	1.44	86,401	5.72	1792	39
88-443	TU 3, L. 1	1.04	20.4	0.98	1.44	86,401	5.72	1799	38
88-444	TU 3, L. 1	1.08	20.4	0.98	1.44	86,401	5.72	1784	40
88-445	TU 3, L. 1	1.01	20.4	0.98	1.44	86,401	5.72	1810	37
88-446	TU 3, L. 1	0.94	20.4	0.98	1.44	86,401	5.72	1833	35
88-447	TU 3, L. 1	1.16	20.4	0.98	1.44	86,401	5.72	1753	42

ages (Table 2). Measurements of the archaeological hydration layers were conducted at 1000× on a polarized Aus-Jena light microscope equipped with an oil immersion lens and image-splitting micrometer. Measurement precision errors, developed from seven readings at one point location, were calculated in all cases to be 0.1 μm or less.

The obsidian hydration ages range from A.D. 1142 to A.D. 1833, with the vast majority of the dates occurring in the second half of the eighteenth century. A summed probability distribution of all the dates (Fig. 8) shows three peaks. The minor peak on the far left is generated from one date in the twelfth century. A second low peak near A.D. 1525 is a result of four artifacts dating to between A.D. 1477–1540. These age estimates are isolated from the main probability distribution and likely represent scavenged artifacts from an older context brought into the cave. We interpret the very large peak of summed probabilities on the right to reflect the construction and use of the AMC which occurred from approximately A.D. 1700–1875 with a peak usage around A.D. 1788.

Sedimentology of the Cave Floor

The floor of the cave was a compacted soil distributed on top of a leveled scoria base to form a living surface. To the naked eye during excavation under low light, the soil matrix was brown in color, but during excavation it was noticed that small patches, or concentrations, of charcoal were present within the matrix. Similarly, restricted concentrations of a red cinder occurred at various locations across the floor. Block samples of these materials within the floor matrix were taken back to the laboratory for a detailed inspection. It was noticed in one block sample that the floor matrix was actually a microstratigraphic profile consisting of alternating layers of dark yellowish brown soil (Munsell 10YR3/4) and white clay (Munsell 5Y8/1). In this block sample from Test Unit 3 (Fig. 9), we were able to see seven distinguishable layers where white clay had been introduced and applied to create a floor surface. At the base of the sample, a 0.5 cm thick layer of white clay represented the first floor installation and the upper layers represented thinner applications later in time. Unfortunately, because of limited sampling, we were not able to map the extent of the clay distribution.

Infrared Analysis of Cave Soils

It was our hypothesis that the white flooring was purposively selected clay, distinct from the soils of the immediate area, which would form a compact living surface. The small layers of brown soil could represent material characteristics of the general terrain introduced by human activity. To evaluate the origin of the brown soil, we first conducted an infrared analysis of an agricultural soil from Planting Pit 28 recovered from a garden at the base of nearby Maunga Orito (Stevenson et al. 2006) since soil from outside the cave was not taken during excavation. We compared the spectrum of the agricultural soil to the reference clays of kaolinite (KGa-2) and montmorillonite (STx-1b) (Fig. 10). Infrared analysis was conducted on a Perkin Elmer Frontier spectrometer with a Pike Technologies attenuated

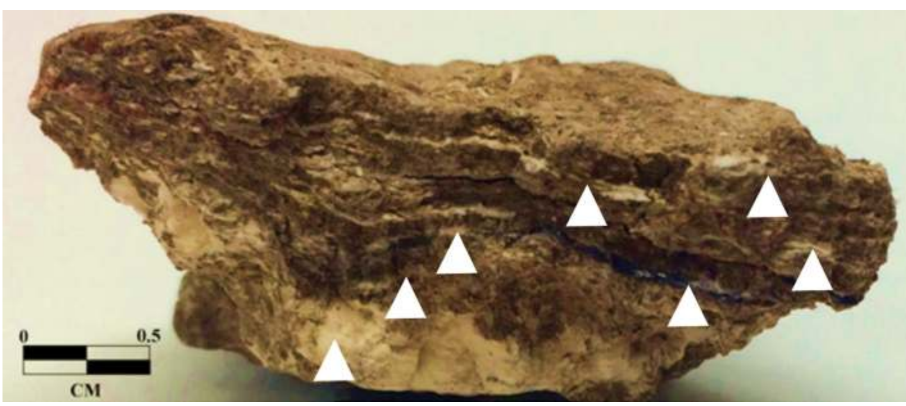

Fig. 9. Cross-section profile of a floor block sample from Site 6-357, Test Unit 3, Level 1. Triangles point to white clay flooring.

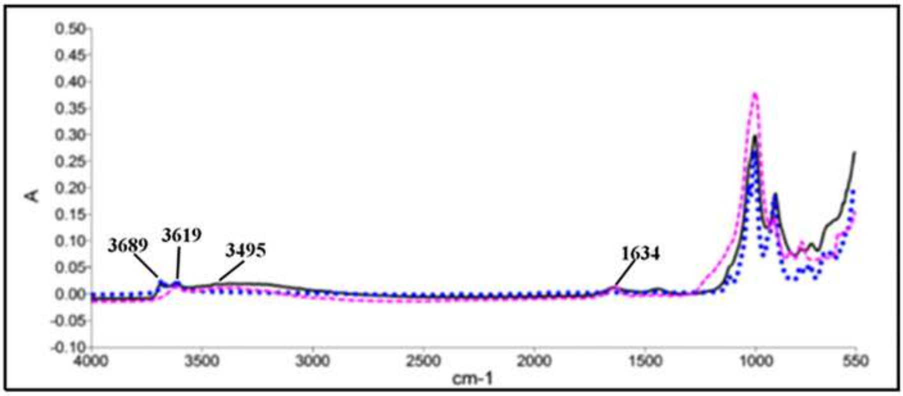

Fig. 10. Infrared spectra of (1) an agricultural soil from Planting Pit 28 at Maunga Orito (solid line), (2) kaolinite (KGa-2) (dots), and (3) montmorillonite (STx-1b) (dashes).

total reflectance (ATR) accessory with a germanium crystal. The soil samples were hand ground and sieved to a powder of 45–25 μm. Each infrared spectrum represents 64 averaged scans collected at a resolution of 8 cm^{-1} and a mirror velocity of 1 cm/s.

The Maunga Orito agricultural soil had a kaolin component as indicated by the hydroxyl bands at 3689 cm^{-1} and 3619 cm^{-1} which reflects the OH stretching of inner surface hydroxyls within the clay microcrystalline structure. Also expressed in this region is the OH stretching of interlayer water at 3495 cm^{-1} accompanied by a broad peak at 3397 cm^{-1} that is characteristic of a 2:1 clay such as montmorillonite. This clay type shows a great affinity for molecular water that is represented by the 1634 cm^{-1} peak for the OH bending mode for absorbed water. Thus, the Maunga Orito agricultural soil appears to have contributions from two forms of clay.

In contrast, the kaolinite component in the brown soil from the cave floor (Test Unit 4, Level 1) is only weakly expressed by the hydroxyl peaks at 3689 cm^{-1} and 3619 cm^{-1} (Fig. 11). The peak for absorbed water at 1634 cm^{-1} is prominent and overlaps a peak at

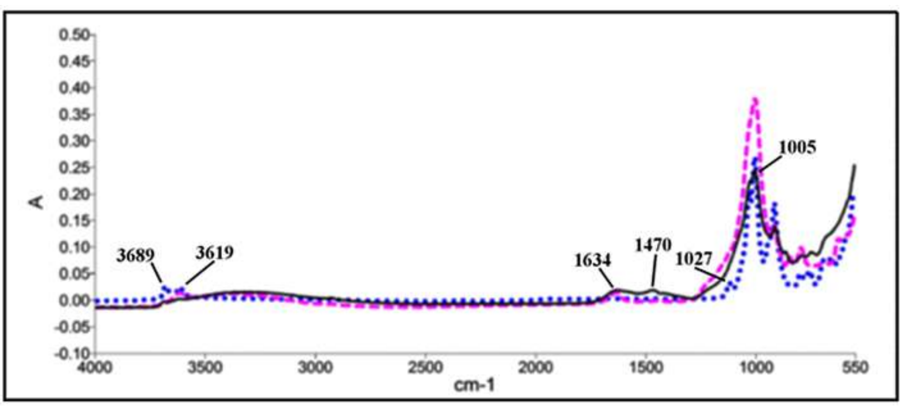

Fig. 11. Infrared spectrum of the brown cave floor soil (Site 6-357, Test Unit 4, Level 1) (solid line) compared to spectra for kaolinite (KGa-2) (dots), and montmorillonite (STx-1b) (dashes).

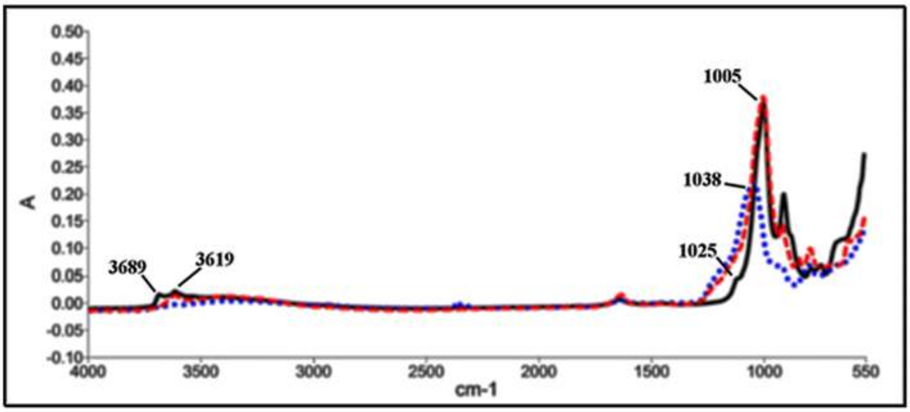

Fig. 12. A comparison of white clay flooring material from (1) Site 6-58 (solid line), (2) Site 6-357 white floor (dots), and (3) montmorillonite STx-1b (dashes).

1470 cm^{-1} which is currently not identified. The Si–O stretching bands in kaolinite at 1027 cm^{-1} and 1005 cm^{-1} are not well articulated and the basal region is broadened at higher wavenumbers which suggests a contribution from a 2:1 clay type; thus constituting a local soil that is slightly different from the Orito sample.

The recurring micro-layers of white clay from our block sample from Test Unit 3, Level 1, was visually similar to a white flooring identified in AMC Site 6-58 located nearby on the southern shoreline of Rapa Nui. This latter material was identified by X-ray diffraction as predominantly a montmorillonite (Stevenson et al. in prep.) with virtually no presence of other types of soil. Our ATR analysis of this clay from 6-58 (Fig. 12) shows a convergence in peak positions with the montmorillonite reference material (STx-2b) except that the Si–O peak at 1025 cm^{-1} is just a subtle shoulder expression. In contrast, the infrared spectrum of the white flooring material from Site 6-357 is significantly different. The hydroxyl peak at 3619 cm^{-1} is very weakly expressed and the 3689 cm^{-1} band is not present. More significantly, the Si–O peak at 1005 cm^{-1} has shifted to higher wavenumbers and is found at 1038 cm^{-1}.

It was our hypothesis that this peak position shift represented a heat treatment of the clay at Site 6-357 before its installation as a floor since any thermal alteration was not possible within the confined subterranean space of the cave. Such peak position shifts have been noted in heating experiments on clays in the laboratory looking at structural changes in clay mineralogy with temperature (Che et al. 2011; Shoval et al. 2011; Stevenson & Gurnick 2016). To confirm this, we conducted an isothermal heating experiment on a sample of floor clay from Site 6-58. The clay was ground in an agate mortar and pestle and sieved to produce a 45–25 μm powder. One gram of powder was loaded into a crucible and placed in a kiln at 100 °C. Every 60 minutes a subsample was removed from the crucible and the temperature increased by 100 °C. This was repeated until the oven maximum operating temperature of 900 °C was reached.

An infrared analysis of each thermally treated subsample was completed using the ATR accessory under the parameters described above. At ambient temperature the Si–O peak position was located at 995 cm^{-1}, a position which it retained up to 400 °C. At 500 °C, the peak location made an abrupt shift to the left by approximately 24 cm^{-1} and continued its movement to higher wavenumbers through 900 °C (Fig. 13, Table 3). Fig. 14 is a plot showing the spectrum of the unheated clay from Site 6-58 compared to the post-heating spectrum of the

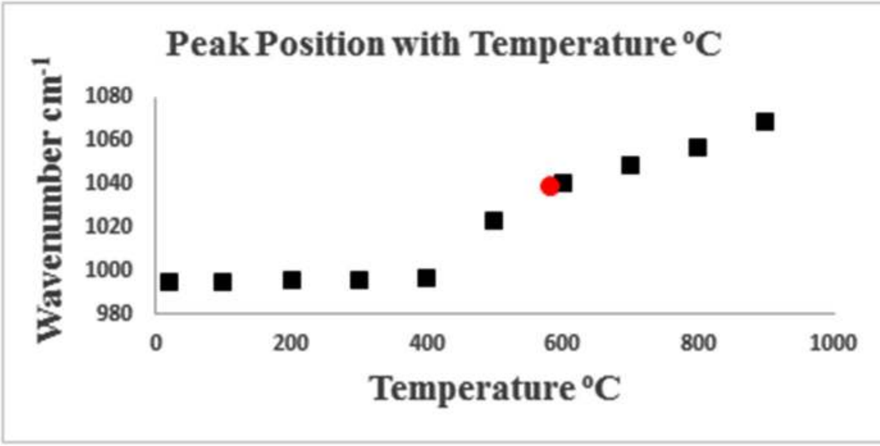

Fig. 13. Shifts in the Si–O peak position for Site 6-58 white floor clay with increasing temperature over a 9 h period. The circular marker represents the peak position of the white clay flooring from Site 6-357.

same material which converges with the spectrum shape of the clay from Site 6-357. This convergence suggests a purposeful heating of the clay installed as a floor at Site 6-357.

Infrared Analysis and X-ray Diffraction Analysis of Red Powders

X-ray diffraction and Fourier transform infrared spectroscopy were used to determine the minerology and composition of two red powders found within the floor matrix. The first sample was a coarse granular scoria-like material from Test Unit 3, Level 1 analyzed by X-ray diffraction (XRD) to determine its mineral composition. The sample was washed with deionized water and dried. Powder XRD was then carried out using a Panalytical X'pert Pro MPD diffractometer (Cu Kα, $\lambda = 1.5418$ Å), with sample pressed onto a zero-background holder. Three individual scans were compiled which had scanning step sizes of 0.005° at 4.00 s per step with the 2θ values ranging from 20° to 80° (Fig. 15).

Table 3. Si–O peak position versus temperature for white clay from Site 6-58.

Temperature (°C)	Peak Position (cm^{-1})
20	994.73
100	994.85
200	995.58
300	995.23
400	996.60
500	1023.34
600	1040.43
700	1048.26
800	1056.40
900	1068.43

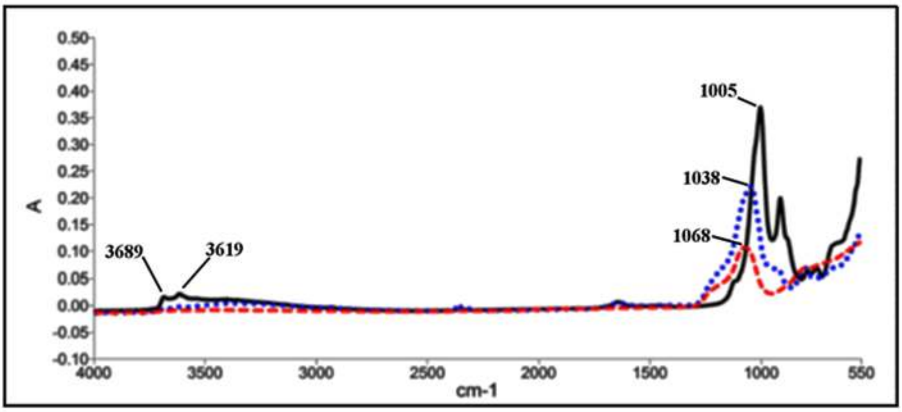

Fig. 14. A comparison of infrared spectra of cave clay floors: (1) unheated clay from Site 6-58 (solid line), (2) white clay floor from Site 6-357 (dots), and (3) thermally altered clay from Site 6-58 heated to 900 °C (dashes).

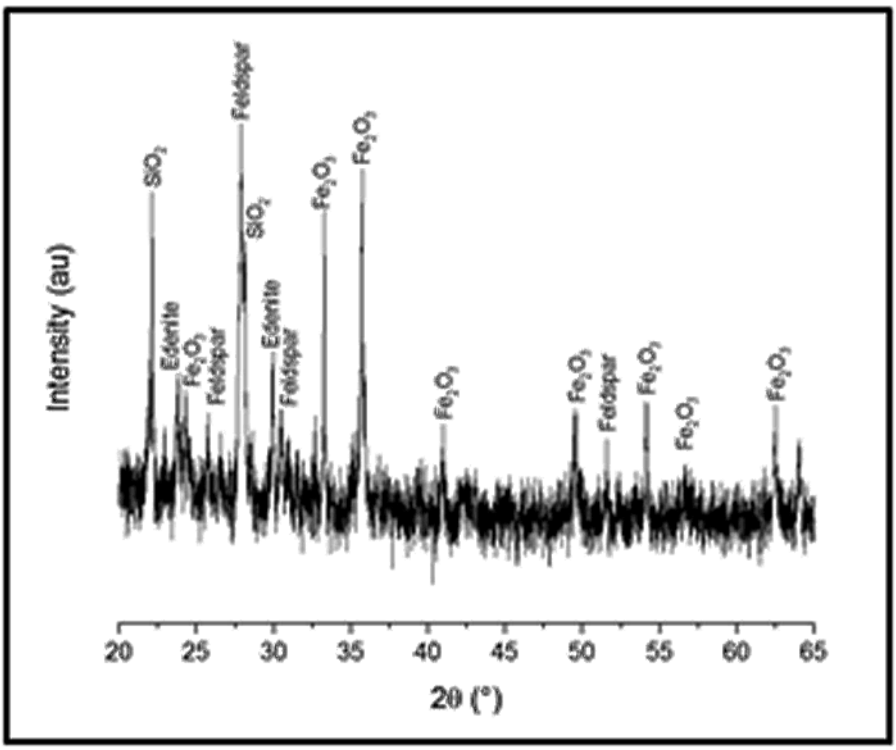

Fig. 15. X-ray diffraction for a red scoria from Test Unit 3, Level 1.

Table 4. X-ray diffraction peak locations and mineral identifications for a red scoria from Site 6-357, Test Unit 3, Level 1.

Peak Location	Identity	Pattern Reference Number
22.084	SiO_2	00-029-0085
23.787	Edenite ($Na_{0.5}(Mg,FeAl)_3(SiAl)_4O_{10}(OH)_2$)	00-029-1235
24.252	Fe_2O_3	01-079-0007
25.71	Feldspar ($CaAl_2Si_2O_8$)	01-041-1486
27.870	Feldspar ($CaAl_2Si_2O_8$)	01-041-1486
28.116	SiO_2	00-029-0085
29.931	Edenite ($Na_{0.5}(Mg,FeAl)_3(SiAl)_4O_{10}(OH)_2$)	00-029-1235
30.46	Feldspar ($CaAl_2Si_2O_8$)	01-041-1486
32.656		
33.253	Fe_2O_3	01-079-0007
35.704	Fe_2O_3	01-079-0007
40.920	Fe_2O_3	01-079-0007
42.370		
49.521	Fe_2O_3	01-079-0007
51.54	Feldspar ($CaAl_2Si_2O_8$)	01-041-1486
54.134	Fe_2O_3	01-079-0007
62.646	Fe_2O_3	01-079-0007
64.029		

Peak positions were compared against the mineral reference library and endenite, feldspar, iron and silica were all identified (Table 4). These minerals constitute hematite, a mineral which could be used as a decorative pigment.

A second red colored material was identified in the floor matrix as scattered 2–3 mm size granules that were soft and clay like. An ATR analysis of this material from Test Unit 4, Level 1, revealed a spectrum with few distinctive features (Fig. 16).

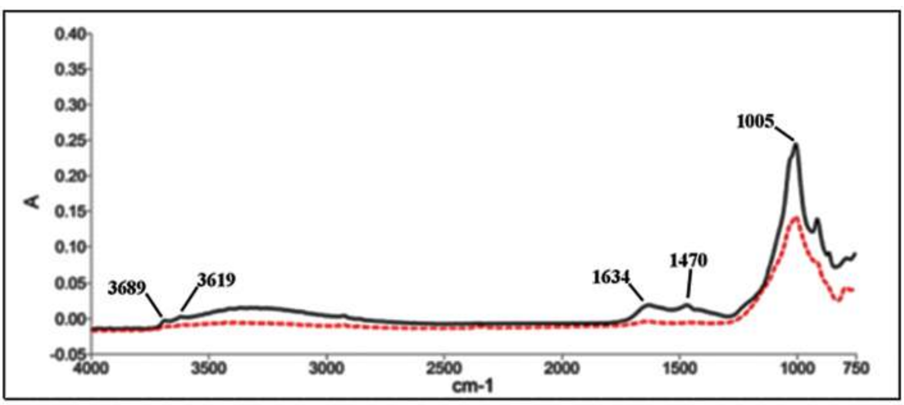

Fig. 16. ATR spectra of brown floor soil from Site 6-357, Test Unit 4, Level 1 (solid line) and reddened soil from the floor, Test Unit 3, Level 1 (dashes).

The absence of the hydroxyl and water peaks suggests an exposure to low temperatures between 100 and 400 °C may have occurred and have been sufficient to oxidize the iron content of the soil. Exposure to temperatures above 400 °C has not occurred since there is no observable shift in the Si–O peak that is still located at 1005 cm^{-1} wavenumbers. This sample may simply represent heated soil inadvertently brought in from the nearby cooking area.

The Ecofact and Artifact Assemblage

The ecofacts from Site 6-357 consist of fish, rat, avifauna skeletal elements, and marine shell, and artifacts include bone needles, obsidian tools and debitage. We summarize the analysis of these materials with the objective of trying to identify how they were used.

Table 5. Metric attributes, bone identifications, and part descriptions for needles from Site 6-357 (uni = unidirectional, b = bidirectional).

Provenience**	Condition	Length (mm)	Width (mm)	Thickness (mm)	Eye Diameter (mm)	Bone Type	Eye Type	Needle Part
TU 3, L. 1	Broken	32.0	2.4	1.2	–	Chicken	–	Shaft
TU 2, L. 1	Complete	57.0	3.2	1.6	1.0	Chicken	uni	–
TU 2, L. 1	Broken	23.5	4.2	1.8	–	Chicken	–	Tip
TU 2, L. 1	Broken	29.0	4.5	1.9	<1.0	Chicken	uni	Base
TU 2, L. 1	Complete	50.0	4.2	1.9	1.0	Chicken	uni	–
TU 4, L. 1	Complete	59.5	2.3	0.6	<1.0	Chicken	uni	–
TU 8, L. 1*	Complete	37.0	3.1	1.5	n/a	Chicken	n/a	–
TU 4, L. 1	Complete	80.5	4.0	1.4	1.0	Chicken	uni	–
TU 2, L. 1	Complete	60.0	3.5	2.3	<1.0	Fish	bi	
TU 3, L. 1	Broken	26.0	3.4	1.6	–	Chicken	–	Tip
TU 8, L. 1	Complete	32.5	3.3	1.6	<1.0	Chicken	bi	Base
TU 9, L. 1	Broken	25.5	3.7	1.5	–	Chicken	–	Tip
TU 6, L. 1	Broken	12.5	3.0	1.4	–	Chicken	–	Tip
TU 7, L. 1	Broken	34.5	3.3	1.4	1.0	Chicken	bi	Base
TU 6, L. 1	Complete	72.0	7.4	1.3	–	Chicken	None	–
TU 7, L. 1	Complete	32.0	2.9	1.2	–	Chicken	None	–
TU 4, L. 1	Broken	16.0	1.4	1.0	–	Chicken	–	Tip
TU 4, L. 1	Broken	31.0	3.8	2.0	–	Chicken	–	Shaft
TU 4, L. 1	Broken	19.5	2.4	0.6	–	Chicken	–	Tip
TU 4, L. 1	Broken	17.0	3.7	1.7	–	Chicken	–	Tip
TU 4, L. 1	Broken	34.5	3.5	1.6	–	Chicken	–	Tip
TU 4, L. 1	Broken	28.5	3.5	1.8	1.0	Chicken	uni	Base
TU 4, L. 1	Complete	59.0	11.0	3.7	–	Human	n/a	Awl
TU 4, L. 1	Incomplete	207	7.1	4.7	–	Human	n/a	Net
TU 8, L. 1	Incomplete	83	7.5	4.9	>1.0	Human?	n/a	Net

*The eye is not completely drilled through the needle.
**All needles are from the cave floor.

Bone Needles

Pointed and polished bone fragments, with a circular eye at one end, have been recovered from other cave sites and interpreted as sewing needles (Beardsley 1996). Katherine Routledge (1919) noted the presence of multiple needles in her casual investigation of architecturally modified caves and Ayres (1975:83) routinely recovered needles from his habitation cave excavations (7 to 167 needles per cave) around the perimeter of the island. Of special note was the recovery of 167 needles by Ayres from an AMC (Site 7-1) located at the edge of the Akahanga *ahu* complex on the southern coast.

At Site 6-357 we recovered 22 complete ($N = 10$), or broken ($N = 12$) bone needle fragments.[2] Twenty-one of the needles, or needle fragments, were made from chicken bone, and one was a fish spine. Other modified bone consisted of an awl of human bone and two items that were long (83–207 mm) and narrow (4.7–4.9 mm) linear tools carved from a whiter colored bone that may be human (Table 5). These could have been tools used in weaving fishing nets, although we are uncertain of this interpretation. All of the whole needles have been shaped to form a pointed end and a broader butt, many of which have a uni-directional or bi-directional drilled eye through which a thread would have passed. The needle shafts and points are well polished from use although some contain deep striations as a result of contact with a harder material (Fig. 17).

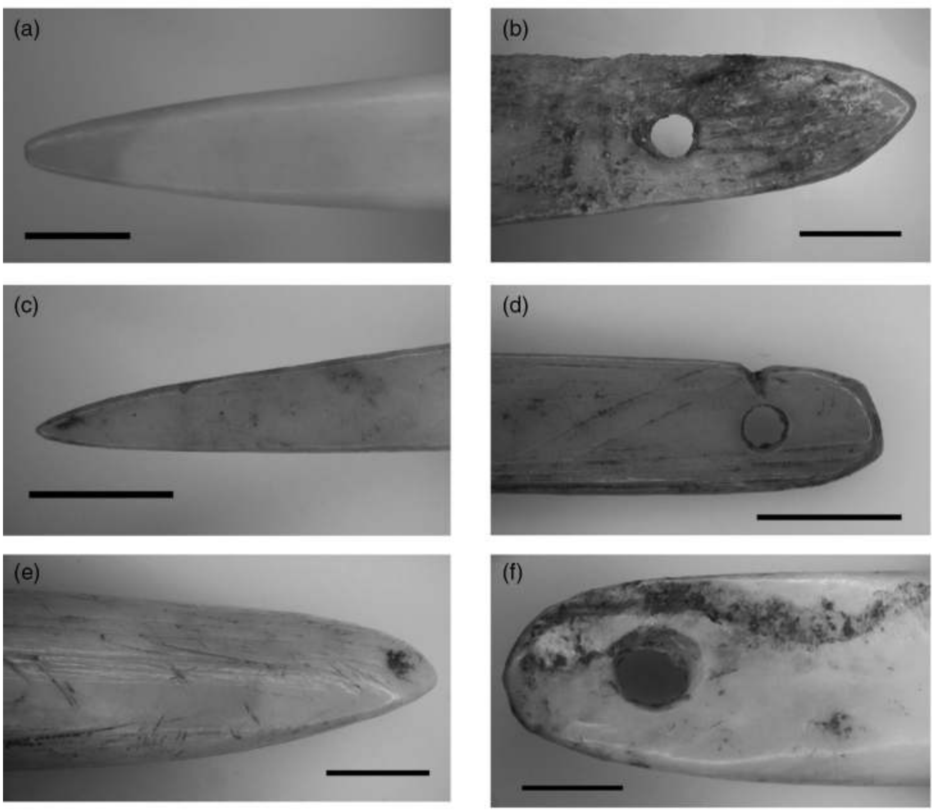

Fig. 17. Bone needle points and drilled ends showing polish and micro-grooves. Magnification is 35× for figures a, b, e, f and 50× for figures c, d. Black bars represent a length of 2 mm.

We entertained the hypothesis that the needles from the floor of the cave may have been a variant of the multi-pronged tattoo comb documented ethnohistorically for Rapa Nui (Métraux 1940:241). Many Rapa Nui tattoos depicted by Métraux (1940:241–246) consist of small filled circles, stick figures, or tightly curved thin lines that may have been difficult to execute with a comb. While many of the needles were sharply pointed and could have pierced human skin to 2–3 mm to produce delicate designs, none of the needles exhibited signs of colored ink staining. Experimental tattooing on pig skin with modern bone needles documents that with repeated penetration of the skin, the tip of the needle will become rounded and ink staining will occur above the depth of needle penetration (Gates St. Pierre 2018). With only the polish and striations as evidence at this point, we suggest that the bone needles may have been used in the sewing of *mahute* (tapa cloth) patches for clothing or the manufacture of *mahute* figurines (*paina*).

Lithic Assemblage Analysis

Rapa Nui's obsidian lithic technology is a unifacial reduction strategy that has a limited diversity of final end products in terms of flake and stemmed tools. It may have remained a conservative and stable tradition during the prehistoric period but a diachronic study of lithic assemblages remains to be completed in order to determine what innovations may have taken place in prehistory. Several researchers have studied either the general reduction sequence (Stevenson et al. 1984), criteria for the selection of expedient flake tools (Allen 1998), or specific tool forms (Bormida 1951; Heyerdahl 1961; Mulloy & Figueroa 1978; Ayres et al. 2000). In this analysis, we focus on a general description of assemblage reduction followed by an analysis of individual tool types and we reference high-magnification edge use-wear analysis to identify specific activities.

Based upon an analysis of an assemblage from the Orito quarry, the obsidian reduction sequence consisted of two general trajectories. Large thick tabular slabs of glass from the quarry are thought to have been preferentially selected for more massive block cores from which large flakes were produced. These large flakes were preferred for the manufacture of *matā* (Stevenson et al. 1984). It has also been noted that large flakes with two ventral surfaces, known elsewhere as *kombawe* flakes, were sometimes produced (Bollt et al. 2006). Most of this primary reduction associated with *matā* manufacture is assumed to have taken place at the quarry, given the labor costs of transporting large amounts of material off-site. It was also proposed that smaller pieces of tabular raw material were preferentially used for the production of small discoidal cores, which could then be easily transported to habitation areas that were removed from the quarry (Stevenson et al. 1984). Thus, the lithic analysis at Site 6-357 was conducted to examine which stages of the core reduction sequence were present.

The excavations resulted in the recovery of 34 whole obsidian flakes and 47 flake fragments. The whole flake assemblage was sorted into primary, secondary, and tertiary flake groups. Primary flakes were defined as those having cortex over the entire dorsal surface, while secondary flakes had a lesser amount of cortex due to previous flake removal. Tertiary flakes possessed no geological cortex on the dorsal surface or striking platform. Each group was then sorted by size category (<2.5 cm, 2.5–5.0 cm, >5 cm). Extensively retouched flakes and formal tools were removed from the assemblage at this point for a separate analysis. All obsidian material was recovered from within 0–5 cm or on the surface of the cave floor.

Table 6. Obsidian lithic reduction categories for Test Units 1–11, Level 1 (0–5 cm) at Site 6-357.

Flake Size	Cortex Primary	Cortex Secondary	Non-Cortex Tertiary
<2.5 cm	0 (0.0%)	2 (5.9%)	9 (26.5%)
2.5–5.0 cm	1 (2.9%)	4 (11.8%)	12 (35.3%)
>5.0 cm	3 (8.8%)	2 (5.9%)	1 (2.9%)
Total	4 (11.8%)	8 (23.5%)	22 (64.7%)

Tertiary flakes were predominant (64.7%), while primary and secondary flakes constituted 23.5% (Table 6), but the low overall number of flakes and fragments suggests that lithic reduction within the cave was unlikely. We therefore believe that most of the obsidian flakes found within the cave were individually imported rather than being manufactured in the low light conditions of the AMC interior. The fact that 68% of the whole flakes are greater than 2.5 cm in length supports a selective process by the past user, as does the fact that most of the larger whole flakes also showed microscopic signs of use-wear (see below). This bias in larger flakes for cutting/scraping tools present at Rapa Nui sites was also noted by Allen (1998) at the nearby domestic habitation (Site 6-345).

Table 7. Flakes, flake fragments, and tools recovered from Site 6-357.

Test Unit	Cortex Fl.	Cortex F.F.	Non-Cortex. Fl.	Non-Cortex F.F.	Tools
TU 3, L. 1	1	1	2	1	*Matā* complete *Matā* stem Graver
TU 4, L. 1	0	3	4	12	Graver (2)
TU 5, L. 1	4	1	3	4	Graver Chopper Waterworn pebble *Matā* complete
TU 6, L. 1	3	14	7	5	*Matā* stem (large) Waterworn pebble (hammerstone)
TU 7, L. 1	1	0	1	2	*Matā* stem (large) *Matā* blade fragment Utilized flake
TU 8, L. 1	2	1	2	1	Graver *Matā* mid-section
TU 9, L. 1	1	1	3	1	*Matā* stem (large)
Total	12	21	22	26	

Table 8. High-power use-wear analysis of obsidian from Site 6-357 (summarized from Church & Ellis 1996). Artifacts are from Test Units 1–11, Level 1 (0–5 cm).

Item	Lithic	Cutting	Whittling	Sawing	Scraping	Plants	Wood	Bone	"Hide"	Fish	Sweet Potato
1	Flake		×				×				
1	Flake			×		×					
1	Flake				×				×		
3	Flake	×				×					
4	Flake	×				×					
6A	Flake			×				×			
6A	Flake				×			×			
6B	Flake				×				×		
6B	Flake				×			×			
8	Flake				×				×		
8	Flake				×		×				
10	Flake	×						×			
14	Flake		×				×				
14	Flake				×					×	
14	Flake	×				×					
15	Flake	×				×					
15	Flake				×				×		
17	Flake	×				×					
18	Flake	×									×
18	Flake			×		×					
21	Flake	×				×					
22	Frag		×				×				
22	Frag			×					×		
23	Flake	×				×					
24	Flake	×						×			
26	Flake	×				×					
27	*Matā*			×		×					
27	*Matā*	×				×					
28	*Matā*	×				×					
30	Flake	×						×			
30	Flake	×				×					
32	Flake	?				×					
33	Flake	×				×					
34	Flake	×				×					
34	Flake				×				×		
35	Flake	×				×					
35	Flake	×								×	
All		19	3	5	8	18	4	6	6	2	1

Unifacially retouched flakes and stemmed tools were also a part of the assemblage (Table 7). Five gravers were characterized by a protruding point on the edge of a flake as a result of retouch. These tools may have been used to score a material. Two complete *matā* and the stem, or blade fragments of six additional *matā*, were also recovered. Two of the stems were disproportionately large, which would imply that the blades on these items were also much larger than the other stemmed tools. Other individual tool forms included a unifacial obsidian chopper and two waterworn pebbles, one of which exhibited battering typical of a hammerstone for obsidian lithic reduction; an attribute that does not fit with our current interpretation of lithic treatment.

High Magnification Lithic Use-wear Analysis

Church and Ellis (1996) conducted a high-magnification use-wear analysis on a sample of artifacts from Site 6-357 to assess their prehistoric uses. Twenty-three flakes, flake fragments, or *matā* were selected from the obsidian assemblage for a functional analysis. A preliminary visual examination of these specimens indicated that each item had been modified through use or retouch and a high-power lithic use-wear was conducted to look at the specific activities associated with each artifact. The methods associated with sample preparation, observation, and interpretation were reported in Church and Ellis (1996).

The motions of cutting, whittling, scraping, and sawing in a back-and-forth motion were identified (Table 8). The motion of cutting was primarily associated with green plant material with less modification noted for bone, wood, fish, or sweet potato. Whittling or sawing of wood or bone were minor activities in comparison to the scraping of "hide," bone, or wood. The scraping of bone could be explained by the manufacture and shaping of bone needles but the obsidian edge modification created by a rough "animal hide" material was not represented by a substance in the experimental reference collection. Since no large mammals are present on Rapa Nui other than humans, it is possible the "hide" may be a coarse fiber such as *mahute* (paper mulberry, *Broussonetia papyrifera*). The alternative of a dried human skin is very unlikely, even though human bones were used to fashion tools.

Faunal Analysis

Excavated faunal remains were analyzed by Rorrer (1997, 1998) in her analysis of Rapa Nui subsistence at two AMCs (6-357, 6-58). In this work, the fish, bird, rat, and larger mammal bones were identified along with the shellfish remains. We summarize her results and their spatial distribution within the AMC.

Fish remains were represented by 3584 bones found within Test Units 1–11 (0–5 cm). The bones were first identified to anatomical element and then to the family level of classification. The elements consisted principally of cranial bones (64.4%), vertebra (33.1%), and shoulder (2.4%) parts, which led to the inference that whole fish were brought to the site without significant pre-processing. These fish consisted principally of wrasse (*Labridae*) (45%) and snapper (*Lutjanidae*) (20%) (Fig. 18). Six other fish species were represented in proportions of less than 3% and these included jack (*Carangidae*), porcupine fish (*Diodontidae*), surgeonfish (*Acanthuridae*), and triggerfish (*Balistidae*). Requiem shark (*Carcharhinidae*) and conger eel (*Congridae*) were also present at this low frequency (<3%) but moray eel (*Muraenidae*) was plentiful (20%). All of the fish represented here originate from habitats at near-shore locations and were likely caught by line angling or nets from shore promontories. None of the species are from deep water. The dominance of wrasse in the assemblage is characteristic of historic period contexts analyzed at other coastal caves (Ayres 1986).

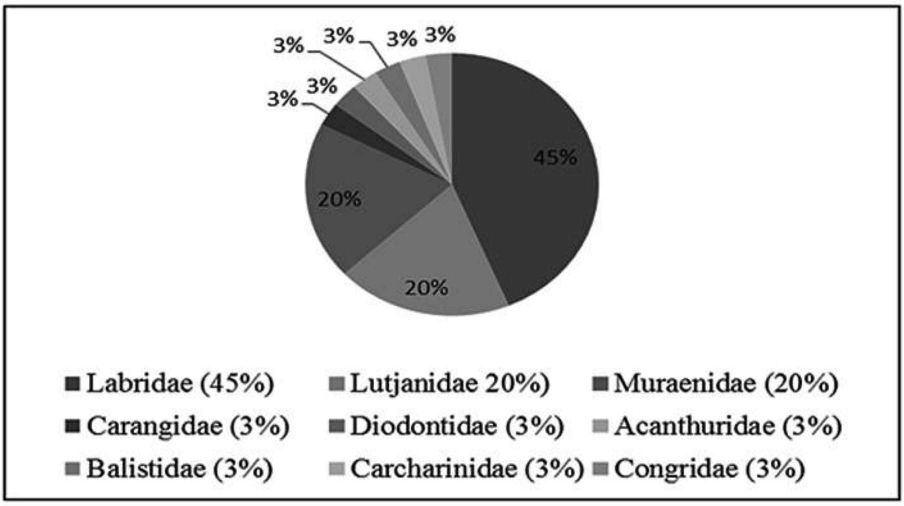

Fig. 18. Percent of fish remains by species from Site 6-357 (from Rorrer 1997).

Bird bones ($N = 1579$) were classified as to class (*Aves*) with the recognition that chicken would dominate the avian assemblage. There are up to 25 species of indigenous avian species (Steadman et al. 1994) and six species have been identified in the faunal assemblages from coastal caves (Speaker-Carr 1980; Ayres et al. 2000) but they are rare in occurrence. Steadman et al. note that native bird bones are the least frequent element in the assemblage from the early stratigraphic deposits behind Ahu Nau Nau on the north coast and do not show a rapid decline as seen on other Polynesian islands (Steadman et al. 1994:92). However, all but one of the strata was radiocarbon-dated to before the fifteenth century and no later material is present for comparison. Site 6-357 is approximately 300 years later and the assemblage represents an MNI of 35 individuals for the chicken (*Gallus gallus*) or 27% of the entire bone assemblage. Rorrer (1998:195) noted that many (89%) of the long bones did not possess articular ends which led her to suggest that marrow was being extracted or that needle manufacturing was being practiced.

Rat (*Rattus exulans*) faunal elements represent 56 individuals based upon the MNI calculation or 10.4% of the faunal assemblage. This commensal rodent is represented by mandible and limb bones. The status of the rat as a food source is unclear, although ethnohistoric evidence suggests occasional consumption (Métraux 1940:19). The bones lack evidence of butchering marks or burning, but cooking the rodent wrapped in banana leaves within an earth oven would protect the skeleton from charring. The notable frequency of rat elements within the cave may indicate consumption or the scavenging of human food remains.

The shell remains embedded within the cave floor consisted of chiton (*Polyplacophora*), nerite (*Neritidae* spp.), cowrie (*Cypraea* spp.), and sea urchin (*Echinometra insularis*). The 582 g of shell recovered from the floor was identified by Dano (1992, cf. Rorrer 1998). Sea urchin is a recognized food source historically (Métraux 1940) and it is likely that the remaining shell types may have been a food source or used in *mahute* (tapa cloth) decoration or head adornments.

Fig. 19. Hand-forged iron metal knife from Site 6-357, Test Unit 5, Level 1.

European Artifacts

Two European artifacts were recovered from the floor of cave. The first was a heavily oxidized hand-forged metal knife made of iron. The handle was no longer present and may have been made of wood or bone, but its absence revealed that the blade and haft were hand-forged from a single piece of metal. The hammer markings associated with this process were still identifiable on the tang (Fig. 19).

A glass trade bead was recovered from the sifting screen in Test Unit 6, Level 1. This was recorded on the test unit field form and the site master notebook, but the object has been misplaced and no additional details are available.

Discussion

Cave interiors on Rapa Nui are one of the few contexts where good preservation and stratigraphic deposits occur together. Archaeologists have capitalized upon this situation to examine resource procurement and changes in subsistence strategies over time (Ayres 1975, 1981, 1986; Ayres et al. 2000). However, the social context of these features is less well understood. The oral history of Rapa Nui suggests an interpretation for architecturally modified caves identified by their tunnel entrances as places of refuge during periods of conflict in the late seventeenth century. Our evaluation of the origin of this interpretation traces it back to an informant of Katherine Routledge in 1914–1915 (Routledge 1919:272) who states it was a place of hiding in "cannibal days," an interpretation tentatively accepted, but with skepticism, by Alfred Métraux. However, more recent reviews of Rapa Nui prehistory have fully accepted this interpretation (Kirch 2000; Flenley & Bahn 2002; Diamond 2005). The lead author of this article also accepted this narrative without question for many years, but finally became skeptical after not finding any additional supportive evidence. A very brief examination of ethnohistorically documented refuge caves in Mangaia and Hawai'i shows these features to be large lava tubes found in remote and difficult to access locations (Kennedy & Brady 1997; Walter & Reilly 2010); a stark contrast to the Rapa Nui context, which started us thinking along alternate pathways.

The similarity in architectural forms between the AMC on the Rapa Nui main island landscape (Stevenson & Haoa 2008), the houses at 'Orongo (Ferdon 1961), and the AMC on the offshore islet of Motu Nui (McCoy 1978) led us to formulate the hypothesis that AMC were connected with the Birdman Cult, and specifically, that the mainland AMC were utilized as places of ritual preparation by the cult contestants (*hopu*). Each of these features has a restricted tunnel opening and a small and dark interior that suggested a similar use of space; but the challenge is to determine if evidence can be found that links the archaeological record of AMC to the ritual center of ‘Orongo. Unfortunately, the investigations at ‘Orongo currently provide little material evidence to identify the cult participants and their place of origin.

At Site 6-357, evidence for a connection with ‘Orongo comes from the association of a *tangata manu* (birdman) petroglyph with the AMC. This figure was carved into the top exterior of the basalt outcrop that formed the roof of the cave. The image of the *tangata manu* (birdman) represents an individual who has won the annual ritual for leadership and it is this person that physically incorporates the spirit of the deity *makemake* during his one-year tenure. Thus, the image is central to the meaning of the cult. Unfortunately, we were not able to identify additional petroglyphs on the walls of the cave interior because of the rough wall texture and low light conditions. In addition, there is no available methodology to temporally link the creation of the surface petroglyph and the activities occurring within the cave. This situation therefore weakens the validity of our hypothesis substantially and we leave its evaluation to future research.

Therefore, we now turn to the approach of defining what constitutes a place of ritual preparation; a space where people call upon deities to assist with life’s challenges. In this analysis, we have found several features of AMC that indicate the labor-intensive preparation of an enclosure that requires the manufacture of architectural components, their assembly, and the construction of a finished interior with materials imported from outside of the cave.

Site 6-357 is a prepared space. The natural cavity formed by a gas bubble in the lava may have originally been used as part of the larger site complex (Site 6-356a–f) but a decision was made to expand the cavity. Its interior was excavated, enlarged, a level floor created, and the debris deposited on top of the basalt outcrop. The cave opening was sealed with larger stone fill and a tunnel entrance with a stone floor constructed. The walls of the tunnel were of rectangular stone (*paenga*) that had been hand-pecked to their final form. In some AMCs, scavenged curbstones from elite houses constitute internal walls or ceilings (Métraux 1940) but no post cupules typical of curbed structures were observed in the building materials used here.

The scoria base of the cave floor was covered with imported white montmorillonite clay that was half a centimeter thick. The reasons for this are obscure. The clay may have reflected the limited indirect light at the cave entrance and increased visibility slightly; but our experience in the cave suggests this would have been marginal. It is possible that small wick lamps were used within the interior to enhance lighting, but none were identified. The clay had been heated prior to installation and this would have dried the damp montmorillonite, which has a high affinity for water. We also suggest that a white floor marked the special nature of the AMC and the color may be associated with purity or sacredness. A reconstruction of color symbolism for Rapa Nui drawing upon ethnographic and archaeological observations suggests that white is associated with the concept of *mana* (Seelenfreund & Holdaway 2000), a spiritual power that would strengthen the occupants during their time in the cave.

The cross-section analysis of a floor block sample clearly indicated that the original clay floor had been refurbished at least six times through the application of additional thin layers of white clay. Over time, brown soil from the exterior was introduced into the cave and formed a thin deposit that obscured the white cave floor. It is not clear if that introduction was through human use or if the cave floor was intentionally covered after a period of time. [A thorough micro-morphological analysis is needed to resolve this issue.] Nevertheless, the activities within the cave do not appear to be continuous, but periodic.

Located on the cave floor were six large and heavy worked stones (*paenga*) approximately 80 cm long, and 40 cm wide, and 20 cm thick. Currently disarticulated, they may have once formed a low platform. The scattered waterworn cobbles (*poro*) found to the west of the *paenga* may also have once been grouped. The other interior feature consisted of a side chamber, also containing a few *poro*. It was not investigated through excavation. Thus, the activities conducted in the space are not known, but are suggestive of a place of increased isolation.

We have proposed that the AMC was a post-European contact (A.D. 1722) construction and the chronological evidence largely supports this hypothesis. The obsidian hydration dating (OHD) from the cave floor show a peak usage around A.D. 1788, with a date range of approximately A.D. 1700–1875 for the major period of use. There are a few (5 of 29) obsidian hydration dates from an earlier period and we attribute this to artifact recycling and the presence of old hydrated surfaces. One of the recurrent and problematic issues of OHD is the inability to detect scavenged artifacts and more rigorous sampling protocols need to be introduced, which might include dating only the ventral surface or flake scars on the artifact cutting edge.

Other chronometric evidence for a post-European contact use of the cave comes from AMS radiocarbon dating. We submitted two charcoal samples identified as grass from within the floor matrix. These samples both returned age determinations of 170 ± 20 B.P. The ages for the corrected samples had the highest probability of occurrence ($p = 0.53$) during A.D. 1728–1785. These dates are not particularly useful in pinpointing the range of site occupation, but they do support the dates produced by the obsidian hydration method.

The presence of European material culture also supports a post-contact cave occupation. A metal knife was recovered from the surface. Although highly oxidized and fragile, it still retains the hand hammering marks made in forming the handle tang. Also recovered from the sieve was a European glass trade bead. Unfortunately, the provenience of these items cannot be indisputably associated with the clay floor and they may have been lost or discarded after regular use of the cave had ended. Nevertheless, all of these chronometric dates and temporal indicators are from the post-contact period.

One of main activities within the AMC was food consumption. Thousands of bones of fish, chicken, and rat were discarded onto the clay floors. Cooking of the food items was conducted outside the cave since any significant combustion within the AMC would have certainly meant suffocation. The adjacent cooking midden with three *umu pae* from the Site 6-356d–f midden (Fig. 2) was the likely place of food preparation. Once cooked, the food items were taken into the cave for consumption.

High densities of faunal elements littered the series of prepared floor surfaces. Fish remains were the most numerous (MNI = 57). The cranial (64.5%) and post-cranial (35.6%) faunal elements of fish indicate that whole fish were delivered to the cave. The identifications of the remains to the taxonomic family show that wrasse (*Labridae*, 45%) and snapper (*Lutjanidae*, 20%) were the two most heavily consumed species. The emphasis on wrasse consumption has been identified by Ayres et al. (2000) from his analysis of the faunal remains at the cave of Runga Va'e (12-208) as a historic period (post-contact) phenomena that reflects a confinement to near-shore fishing. The use of this littoral zone is also evidenced by the higher frequencies of eel (*Muraenidae*, 20%), which are often found in tidal pools or crevices near the shoreline. Larger cuts of deep water pelagic fish are not part of the diet and no specialized diets are associated with fish. This also seems to apply to the bird bones that are inferred to be predominantly chicken (*Gallus gallus*) (MNI = 35) and rat (*Rattus exulans*) bones, which represent 56 individuals.

The 5720 faunal elements are distributed within 11 m^2 of excavated floor area that is less then 5 cm in thickness. With an average of 520 elements per excavation unit, it appears that the clay floor of the AMC was not pristinely maintained. It could be argued that the presence of substantial refuse and the absence of cleaning indicated that the use-life of a floor was of short duration, maybe for a few weeks or a month, and that in lieu of cleaning the AMC, the food debris was simply covered over with fresh earth. This is supported by examining a segment of the floor stratigraphy in cross section. The sample from Test Unit 3, Level 1 in Fig. 9 shows the intervening layers to be 1–3 mm thick and the thin clay floor applications to be intact. The preservation of this microstratigraphy in the center part of the cave opposite the entrance would not be expected if the cave was entered and exited continuously over time.

The obsidian assemblage recovered from the floor is numerically low and consists of 81 flakes/flake fragments and 14 recognizable tools based upon unifacial flaking or edge damage (Table 7). These low amounts of debitage indicate that lithic reduction was not conducted within the confines of the AMC, even though one small waterworn pebble with battering on one end suggests its use as a hammerstone. Therefore, it is more likely that individual objects were brought into the cave as needed for activities of the moment.

Even with the absence of lithic reduction activities, primary, secondary and tertiary flakes from all stages were present. Primary flakes have cortex on the entire dorsal surface and secondary flakes possess cortex on an edge or partial coverage on the dorsal surface. These flakes are typically indicative of core preparation (Stevenson et al. 1984), which is in this case apparently absent from the cave confines. It may be that the occupants of the cave were looking for larger flakes associated with the first phases of reduction and/or that the rough surface cortex was useful within the context of certain activities. These flakes may have been prepared on the main site activity area or scavenged from the immediate surface, which contained a dense assemblage of debitage ($N = 29{,}156$) recovered by systematic surface collection during the cave excavation (Stevenson 1988). It is this scavenging behavior which can be problematic for the delineation of activities within the AMC.

With this caveat in mind, the use-wear analysis of Church and Ellis (1996) indicated the main processing activities that occurred within the AMC were the cutting of green plants and the scraping of a material similar to animal hide. The cutting and scraping of these and other materials such as bone and wood were conducted using simple flakes, unifacial gravers, and tanged *matā*. Church and Ellis (1996:87) also argue that a prepared cave interior, "the intensive use of expedient flakes," and the variety of domestic activities all reflect an extended stay for persons residing in what they accepted as a refuge cave. In and of themselves, these attributes are not indicative of refuge, or ritual, but are simply correlates about the duration of cave occupation. In addition, Church and Ellis (1996) also remark that the range of tool forms, and thus the implied range of activities, is substantially less than artifact forms documented by Smith (1961) for domestic habitation caves.

Our final piece of evidence about activities within the cave consists of the bone needles found on the floor. All previous investigations of AMCs have remarked on the high frequency of occurrence for this artifact form (Routledge 1919; Ayres 1975). Striations observed on our sample at high magnification, and the lack of ink staining, suggest they were used for deeply penetrating motions such as sewing rather than tattooing. Sewing on Rapa Nui was an activity largely connected with piecing together small pieces of *mahute* (tapa cloth) into robes of various sizes worn over the shoulders and down the back to form a barrier against the rain and cold (Métraux 1940:218). However, the creation of reed images (*paina*) held together by an exterior casing of *mahute* (tapa cloth) were also hand-sewn and decorated with red and black pigments. Oral accounts connect these 4 m-long images with the *paina* feast and the honoring of a deceased father at the *ahu* (Métraux 1940:344). Their large size likely precludes their introduction into the AMC.

In summary, it is clear from the architectural fabric and microstratigraphy that the AMC was a carefully prepared and repeatedly occupied space that was post-contact in origin. The nature of the activities conducted within the cave focused on food consumption, especially fish, processing of green plant material, sewing, and the application of pigments. While the meaning of these associated activities is not fully revealed by the archaeological correlates that we have applied to the material remains, it does not strongly support the interpretation of the AMC as a place of refuge from groups of people under threat.

There are no established archaeological correlates for places of refuge since the size of communities under threat, the forms of violence, and its duration, can vary substantially. For short-term skirmish warfare typical of tribes and chiefdoms, we could reasonably predict that small communities would retreat to places for very limited durations (hours to days) with limited food supplies in areas away from their known home location. However, the specifics of the AMC at Site 6-357 meet none of these expectations. The AMC is located in a highly visible domestic area and the restricted cave size suggests that a community of 15–20 people could not be accommodated easily. Under such crowded conditions, one would expect daily activities to be highly limited, yet we find evidence for sewing and decoration and ample food consumption. All of these features argue for an alternate interpretation of this architectural feature.

Conclusion

AMC on Rapa Nui are formalized architectural spaces created from irregular below-ground lava bubbles. At Site 6-357, the narrow tunnel entrance into the cave was of worked blocks and the interior floor was leveled and covered with white clay to prepare a confined space. A platform of cut stones and a pavement of waterworn cobbles were added along with a side chamber. We argue that for the past occupants of the cave, the intention was to create a private space with limited access to the outside world. Caves with these features are architecturally distinct from habitation caves, which have only limited embellishments such as exterior stacked stone walls of field stone that may define a living surface in front of the cave entrance (Smith 1961; Stevenson & Haoa 2008). They are also different from ethnographically reported refuge caves elsewhere in Polynesia, which tend to be remotely located and large in size. Couple these observations with a more limited diversity of material culture than typically encountered in habitation caves (Smith 1961) and these attributes argue for more limited activities occurring within the cave that differ from those of ordinary daily life.

We have argued that one mark of ritual activities is their repetitive occurrence, and this is evidenced by the addition of new floor surfaces over time. The preservation of these thin clay applications suggests that the occupation of the cave was not continuous, or long-term, as these fragile installations would not be as well-preserved as they are. We therefore conclude that the occupants' use of the cave was planned, purposeful, and event-driven. The intervals between the events cannot be determined, but they occurred during the post-European contact era as the obsidian hydration dating, radiocarbon dates, and European artifacts indicate.

Because of the temporal overlap in cave occupation with activities at 'Orongo, and the presence of a *tangata manu* (birdman) petroglyph near the entrance, we are tempted to infer that the occupants of the cave were either clan warriors (*matatoa*) or the contestants (*hopu*) in the *tangata manu* ritual. These individuals would have had to prepare themselves spiritually, physically, and decoratively for the extensive social interaction at ʻOrongo and the excursion to the islet of Motu Nui. Unfortunately, the evidence to support this hypothesis is lacking.

Our reinterpretation of refuge caves (*ana kionga*) as ritual enclosures, if correct, changes the larger picture of Rapa Nui cultural development. Another piece of traditional evidence for conflict in the seventeenth century (Flenley & Bahn 2002; Diamond 2005) now seems less plausible. This chronological assessment and reinterpretation of the archaeological record suggests that some of the twentieth century oral history may be exaggerations, or one person's personal experience, rather than a reflection of what actually happened in the past. Yet, it would be foolish to think that the Rapanui lived for centuries in a blissful utopia without internal conflicts. There are many caves on Rapa Nui on cliff faces and under lava bubbles that may have indeed served as refuge locations, but we have not learned the material expressions of refuge characteristic of this island.

Lastly, our investigation of Site 6-357 begs the question as to why the Rapanui created a new form of ritual enclosure after many centuries of settlement on the island. We propose that the trauma of European contact may have initiated abrupt changes in society. A few short-term European contacts may have rapidly impacted the cultural traditions and political structure of Rapa Nui significantly through the introduction of new material objects (e.g., glass, metal, clothing) and possibly communicable diseases prior to the smallpox epidemic of the late 1860s. In light of our analysis, we hypothesize that rapid change at the household level in the eighteenth century does not appear to originate from long-term environmental problems such as drought, or soil nutrient depletion, and that these explanations are now less compelling prime movers. Our approach to cultural change on Rapa Nui should therefore be multivariate and weighted differently over time in order to fully explain the past social dynamics that we observe.

Notes

[1] In Stevenson and Williams (2018) the activation energy was reported as 86,391 J/mol rather than 86,401 J/mol as a result of a typographical error. This reflects a 0.0002% error for this parameter and the impact on the age estimates.

[2] Church and Ellis (1996) note that only four bone needles were present. We are not sure why the entire quantity of 22 needles was not mentioned.

Acknowledgments

We would like to thank the Consejo de Monumentos Nacionales, Santiago, and the Consejo de Monumentos, Rapa Nui, for permission to conduct archaeological research. We also thank Katherine Rorrer and Flora Church for their artifact analyses and William S. Ayres for his decades of friendship and academic support. Our gratitude goes to Patrick McCoy who provided a thorough and detailed assessment of the manuscript as part of the review process.

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