CUEVA HUENUL 1 ARCHAEOLOGICAL SITE, NORTHWESTERN PATAGONIA, ARGENTINA: INITIAL COLONIZATION AND MID-HOLOCENE DEMOGRAPHIC RETRACTION

Ramiro Barberena

In this paper I present an intensively dated chrono-stratigraphic sequence for the Cueva Huenul 1 archaeological site, Neuquén Province, Argentina. Located in the inland deserts of northwestern Patagonia, Cueva Huenul 1 offers a remarkable temporal record of events for a largely unstudied desert region. I connect this local record with available data on a macro-regional scale to reassess (1) the timing of the first human colonization of the area and its implications for explaining the extinction of megafauna (ca. 14,000–10,000 cal B.P.) and (2) the decrease in human occupation recorded in several South American deserts during parts of the mid-Holocene (ca. 8000–6000 cal B.P.). The data presented here show a gap of about 1,500 calendar years between the extinction of megafauna and the appearance of humans. A review of evidence from the northern Patagonia and southern Cuyo regions is consistent with this record, favoring ecological causes for regional extinction of megafaunal taxa. Integration of this record with those indicating the earliest human presence in South America (e.g., Monte Verde, Chile) is consistent with a process of human radiation to the inland Patagonian deserts from nodes of initial occupation. The chrono-stratigraphic sequence from Cueva Huenul 1 also contributes to an assessment of a trough in human occupation along the South American Arid Diagonal around 8000–6000 cal B.P. Evidence for a decrease in occupational intensity during this period is found in the highland and lowland deserts in Mendoza and San Juan, the Puna region in northwestern Argentina, the Atacama Desert in Chile, and possibly the Pampean region. Previous researchers have suggested that persistent arid conditions would have produced increasing landscape fragmentation, particularly affecting desert areas. A more specific understanding of the demographic processes underlying this archaeological signal is needed. In this paper I suggest that this trough reflects not only spatial and social rearrangements, but also a macro-regional demographic retraction. This could have caused a population bottleneck with lasting biological and cultural implications.

*En este trabajo presento la secuencia crono-estratigráfica del sitio arqueológico Cueva Huenul 1 (Provincia del Neuquén, Argentina), la cual ha sido datada en forma intensiva. El sitio se emplaza en el desierto del noroeste de Patagonia y presenta un registro excepcional de eventos históricos para una región escasamente estudiada. Vinculo este registro con la información disponible en una escala macro-regional y reanalizo (a) la fecha de la primer presencia humana y sus implicancias para la extinción de la megafauna (~14000–10000 años cal a.P.); y (b) la disminución en la intensidad de la señal arqueológica registrada en múltiples desiertos de Sudamérica en partes del Holoceno medio (~8000–6000 años cal a.P.). Los datos revelan un hiato de ~1500 años calendáricos entre la primera presencia humana y la última presencia de megafauna. Una revisión de la evidencia disponible para el norte de Patagonia y el sur de Cuyo es consistente con este registro local, favoreciendo una causa ecológica para la extinción de la megafauna. La integración de este registro con aquellos que reflejan la ocupación más temprana de Sudamérica (*v.g.* localidad Monte Verde) sugiere un proceso de radiación humana desde los nodos de colonización inicial a ambientes marginales de Patagonia. La secuencia crono-estratigráfica de Cueva Huenul 1 tambien contribuye a una evaluación de la disminución ocupacional registrada en torno a 8000–6000 años cal a.P. Este registro abarca desiertos de altura y planicies bajas de las Provincias de Mendoza y San Juan en Cuyo, la Puna en el noroeste de Argentina, el desierto de Atacama en Chile, a los cuales se suma el posible caso de la región pampeana. Diversos investigadores han propuesto que condiciones áridas persistentes habrían producido un proceso de fragmentación del paisaje que afectó a áreas desérticas en particular. Actualmente, se requiere un análisis más específico de los procesos demográficos que subyacen esta señal arqueológica macro-regional. Aquí sugiero que esta disminución en la intensidad de la señal arqueológica refleja no sólo una reorganización espacial, sino también una retracción demográfica, que podría haber conducido a un cuello de botella poblacional con importantes consecuencias biológicas y culturales.*

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The timing of the human colonization of South America is a key issue for models of the exploration and peopling of empty landscapes and the extinction of megafauna (Barnosky and Lindsey 2010; Borrero 2008; Dillehay 2008). Although relatively little is known about these topics, a recently published corpus of information is producing new perspectives and challenges (see papers in Bueno et al. [2013]). Multiple South American deserts also show evidence of decreased human occupation during parts of the mid-Holocene (8000–6000 cal B.P.; Grosjean et al. 2007; Méndez et al. 2015; Yacobaccio 2013). Contrasting suggestions on the causes and social implications of this record have been put forth, although we still need a better understanding of the underlying macro-demographic processes.

In this paper I present an intensively dated chrono-stratigraphic sequence for the Cueva Huenul 1 archaeological site, Neuquén Province, Argentina. Located in the inland desert of northwestern Patagonia, Cueva Huenul 1 offers a remarkable temporal record of events for a largely unstudied region. I connect this local record with available data in order to reassess these demographic problems and suggest new scenarios for discussion. Using appropriate analytical schemes, site-scale archaeological data contribute to addressing large-scale issues.

South American Deserts and the Cueva Huenul 1 Site

The Andean mountain range is a high and relatively continuous topographic feature that disrupts patterns of atmospheric circulation, directly impacting South American climate and ecology (Garreaud 2009). In the southern Andes (35–53° S), climate is controlled by the westerly winds, producing a remarkable rain-shadow effect. The western Andean forests receive more than 2000 mm annually, but the eastern steppes and shrub-steppes of Patagonia receive less than 300 mm (Páez et al. 2004). In contrast, at the tropical and subtropical latitudes north of 30° S, arid conditions prevail along the Pacific coast and extend into the western slopes of the Andes, while warm humid conditions associated with atmospheric circulation from the Atlantic Ocean prevail over the eastern slopes. These combined rain-shadow effects produce the South American Arid Diagonal, a continental geologic-climatic feature including desert and semi-desert ecosystems (Figure 1).

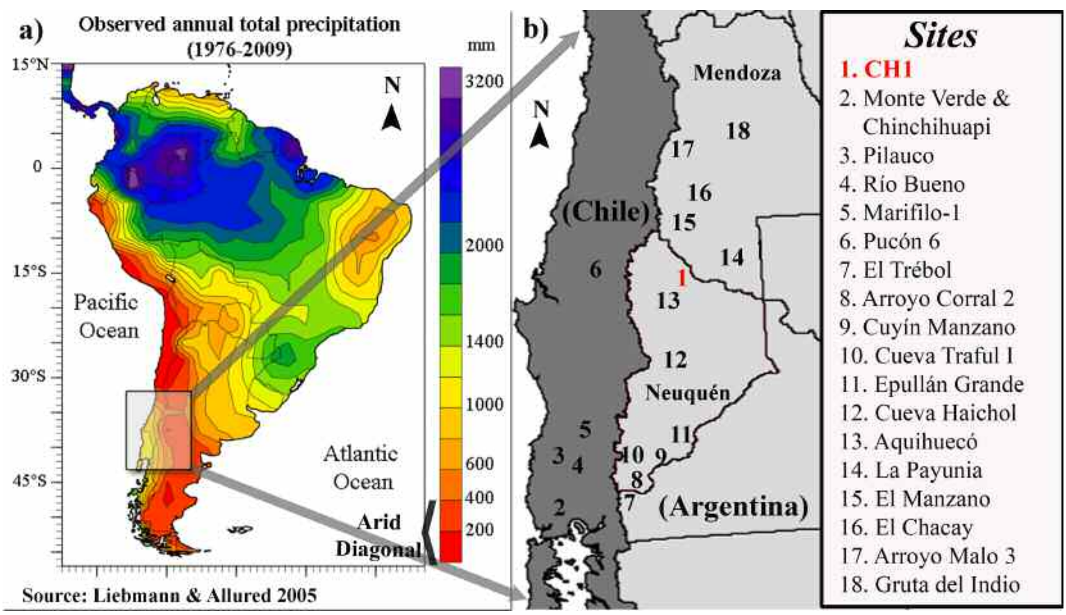

Figure 1. Study area: (a) Distribution of precipitation and South American Arid Diagonal (based on Liebmann and Allured [2005]); (b) location of CH1 and other sites mentioned (35–41º S).

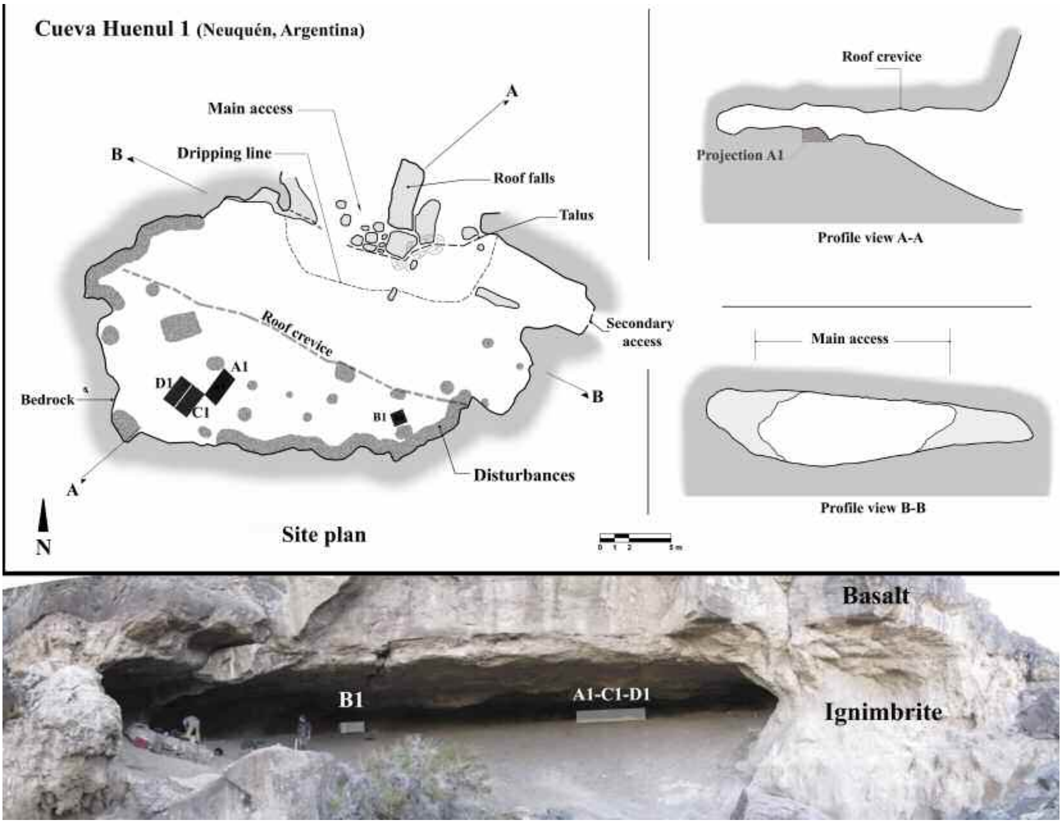

Figure 2. CH1: (above) site plan and profile views; (below) photograph.

The Cueva Huenul 1 site (hereafter CH1; 36º 57' S, 69º 49' W; 1,000 m asl) is located in a desert environment within the Monte phytogeographical Province, a scrubby formation typical of northern Patagonian deserts (Abraham et al. 2009; Páez et al. 2004). This region is ecologically sensitive for two reasons: (1) it is located in the transition zone between Pacific-dominated precipitation to the south and Atlantic-dominated precipitation to the north (Garreaud 2009), and (2) it is close to the western limit of the Monte Desert at this latitude. These transitional conditions make it a sensitive spot for tracking paleoecological change through the Late Quaternary.

CH1 is a large cave formed by erosion of the contact between ignimbrites of the Tilhué Formation at the bottom and basalts of El Puente Formation on top (Figure 2). A stable microenvironment with predominantly dry conditions within the cave has allowed for excellent preservation of organic materials. Argentinean archaeologist Jorge Fernández tested CH1 in 1978, obtaining a ^{14}C age of 11,150 ± 230 B.P. for a sample of unknown composition and provenience (Cordero et al. 2002). The presence of late Pleistocene deposits and signs of recent human impact suggested that further sampling would be useful for exploring early human colonization of Patagonia (Barberena et al. 2010).

Excavations were conducted in two sectors of the cave in order to assess stratigraphic variation (Figure 2). Three quadrats of 2 x 1 m (A1, C1, and D1) were placed in the deepest zone of the cave, where the upper deposits were better preserved, reaching a maximum depth of 1.4 m (2.8 m^3 of excavated volume). Test pit B1 (1 x 1 m) was placed closer to the mouth of the cave and reached a maximum depth of .95 m (.95 m^3). Underlying bedrock was exposed in both cases. We present here a chronological and stratigraphic study of the two excavation areas, although detailed quantification of the materials is only presented for Quadrat A1.

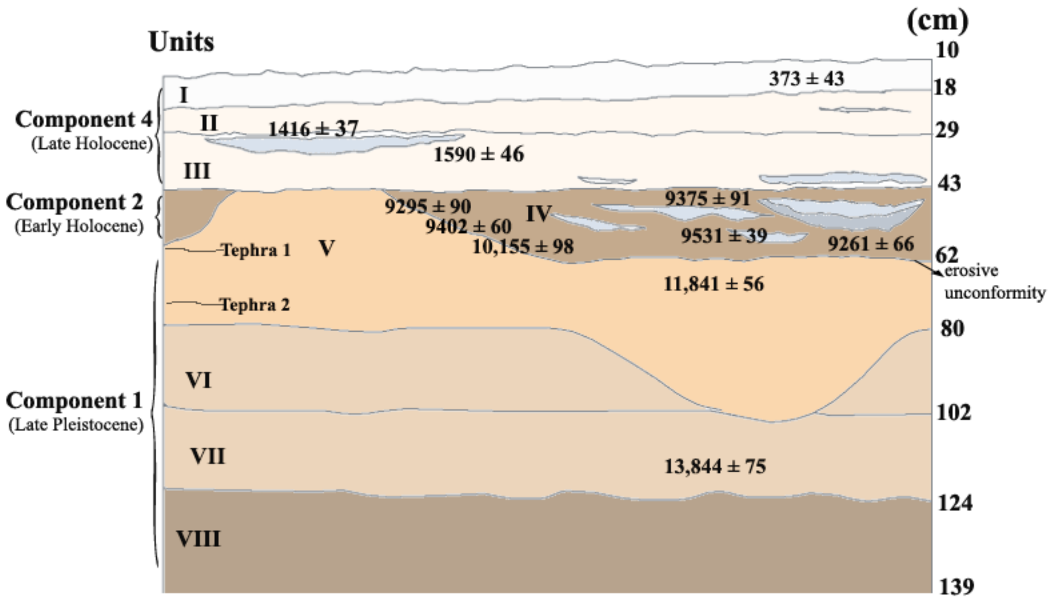

Figure 3. Stratigraphy of CH1: Quadrat A1, south profile (Component 3 was not recorded in this quadrat).

Methods

The excavation was carried out in 10-cm artificial levels and all natural sedimentary layers were differentiated. Temporal components were defined on the basis of stratigraphic and chronological criteria, and hiatus were recorded on the basis of stratigraphic unconformities and temporal breaks in the sequence.

Radiocarbon dates were processed at the National Science Foundation AMS Laboratory, University of Arizona. The ages were calibrated in OxCal 4.2 using the SH13 curve (Hogg et al. 2013) and were graphed with the probability sum command in OxCal (Bronk Ramsey 2009). Unless otherwise indicated, all ages discussed are in calibrated calendar years B.P.

Results

Chrono-stratigraphy

The sequence in Quadrats A1, C1, and D1 is composed of eight stratigraphic units defined in the field, and organized in three temporal components (Figure 3). Stratigraphic Units VIII through V (excavation Levels 14–6) have high percentages—up to five percent—of organic matter in a matrix composed of fine sediment. These units make up the basal Component 1. The organic content consists largely of macro-remains of shrubby plants. Embedded in the matrix, a large number of very well preserved coprolites were recorded. Their size and morphology indicate that they correspond to small carnivores and the megafaunal taxon *Pilosa* (see Martínez et al. 2010), which includes herbivores such as ground sloths. Two dates were obtained for coprolite samples from Units VII and V, producing bracketing median ages of 16,695 and 13,631 cal B.P. These dates bracket Component 1 (Table 1). The top of these units is delimited by a distinguishable erosional unconformity referred to as Hiatus 1 (Figure 3). Two distinct tephra layers were recorded within Component 1. Geochemical analyses by Charles R. Stern (University of Colorado Boulder) indicate that they would correspond to the local Tromen volcano (Barberena et al. 2015a).

In direct contact with the unconformity comes stratigraphic Unit IV, including Levels 4–5, which were about 20 cm thick. These levels are defined as Component 2. They are different from the layers making up Component 1 in terms of sedimentary texture, color, and composition, and do not include coprolite-derived organic matter (Bar-

Table 1. Radiocarbon Dates from CH1.

Sample	Provenience	Unit	Material	^{14}C Age	Calibrated Age B.P. (2σ)	Median (cal B.P.)	Lab Code (AA)
Quadrats A1 and C1							
CH1.6	A1. Level 1W (10-20 cm)	I	*Lama guanicoe* (metapodial)	373 ± 43	312-489	396	99102
CH1.4	A1. Level 2E(20-30 cm)	II	grass (bedding structure)	1416 ± 37	1185-1354	1291	85721
CH1.7	A1. Level 3E(30-40 cm)	III	*Lama guanicoe* (tibia)	1590 ± 46	1323-1537	1440	99103
CH1.16	C1	Structure G	*Senna aphylla* (twigs)	4786 ± 46	5324-5588	5487	102575
CH1.8	A1. Level 4W(40-50 cm)	IV	*Lama guanicoe* (radius-ulna)	9375 ± 91	10249-10763	10535	99104
CH1.9	A1. Level 4E(40-50 cm)	IV	*Lama guanicoe* (humerus)	9295 ± 90	10236-10659	10432	99105
CH1.15	A1. Level 5E(50-60 cm)	IV	*Prosopis* sp.(seed)	9402 ± 60	10303-10747	10578	102574
CH1.1	A1. Level 5W(55-57 cm)	IV	charcoal (hearth #2)	9531 ± 39	10588-11070	10750	85718
CH1.10	A1. Level 5E(50-60 cm)	IV	*Lama guanicoe* (metapodial)	10155 ± 98	11294-12032	11694	99106
CH1.11	A1. Level 5W(50-60 cm)	IV	*Retanilla patagonica* (fruit)	9261 ± 66	10242-10557	10388	99100
CH1.3	A1. Level 5W(50-60 cm)	V	coprolite (megafauna)	11841 ± 56	13481-13748	13631	85720
CH1.5	A1. Level 10W(100-110 cm)	VII	coprolite (megafauna)	13844 ± 75	16390-16985	16695	85722
Test-pit B1							
CH1.12	Level 2	I	*Lama guanicoe* (humerus)	1269 ± 46	998-1271	1143	99109
CH1.14	Level 5	III	*Lagenaria* sp.(gourd)	541 ± 42	491-622	526	102573
CH1.13	Level 6	III	*Lama guanicoe* (radius-ulna)	1753 ± 47	1528-1727	1628	99110

Figure 4. Excavation of Quadrats C1 and D1, Level 6.

berena 2014a). Five directly dated archaeological samples from Unit IV produced ages of 11,000–10,200 cal B.P. and another sample was dated to 12,000–11,300 cal B.P. (Table 1). The latter could represent either an earlier occupation period that was not discriminated in the stratigraphy, or a statistically insignificant outlier.

Some sedimentary features of the Holocene occupations intruded the top of the Pleistocene levels. These features include beds of grass, an earth oven, and at least two pits filled with plant material. One of them, named Structure G and located in Quadrat D1, was filled with shrubby vegetal material determined to be *Senna aphylla* (Carina Llano, personal communication 2013), a taxon that is typical of the Monte Desert community. The sample was dated to 5600–5300 cal B.P. (Figure 4). This pit is the only evidence pertaining to the mid-Holocene at CH1 and is defined separately as Component 3.

Component 4 consists of Stratigraphic Units III–I and is dated to 1500–300 cal B.P. The lower limit of this component is not associated with significant stratigraphic breaks and was determined mainly on the basis of a large chronological gap (Figure 5). Test pit B1 produced a basal date of 1727–1528 cal B.P. and a more recent date of 622–491 cal B.P. for a sample of domesticated gourd (*Lagenaria* sp.).

Although it discontinuously represents 11,500 calendar years overall, the Holocene segment of the sequence is very shallow, only up to 60 cm thick. In conjunction with the presence of intrusive sedimentary structures, such as the pit defining Component 3, this leads to the conclusion that the assemblages have low temporal resolution. Nonetheless, the vertical distribution of dates indicates that there is temporal consistency in the defined components. This is confirmed by the vertical distribution of archaeological materials, as discussed below.

Archaeological Materials and Intensity of Human Occupation through Time

Figure 6 presents the relative proportions of different types of materials from Quadrat A1: lithic artifacts, macro- and micro-faunal remains, macro-botanical remains, and carnivore coprolites (which have very good preservation even in late Pleistocene levels). Details of these assemblages

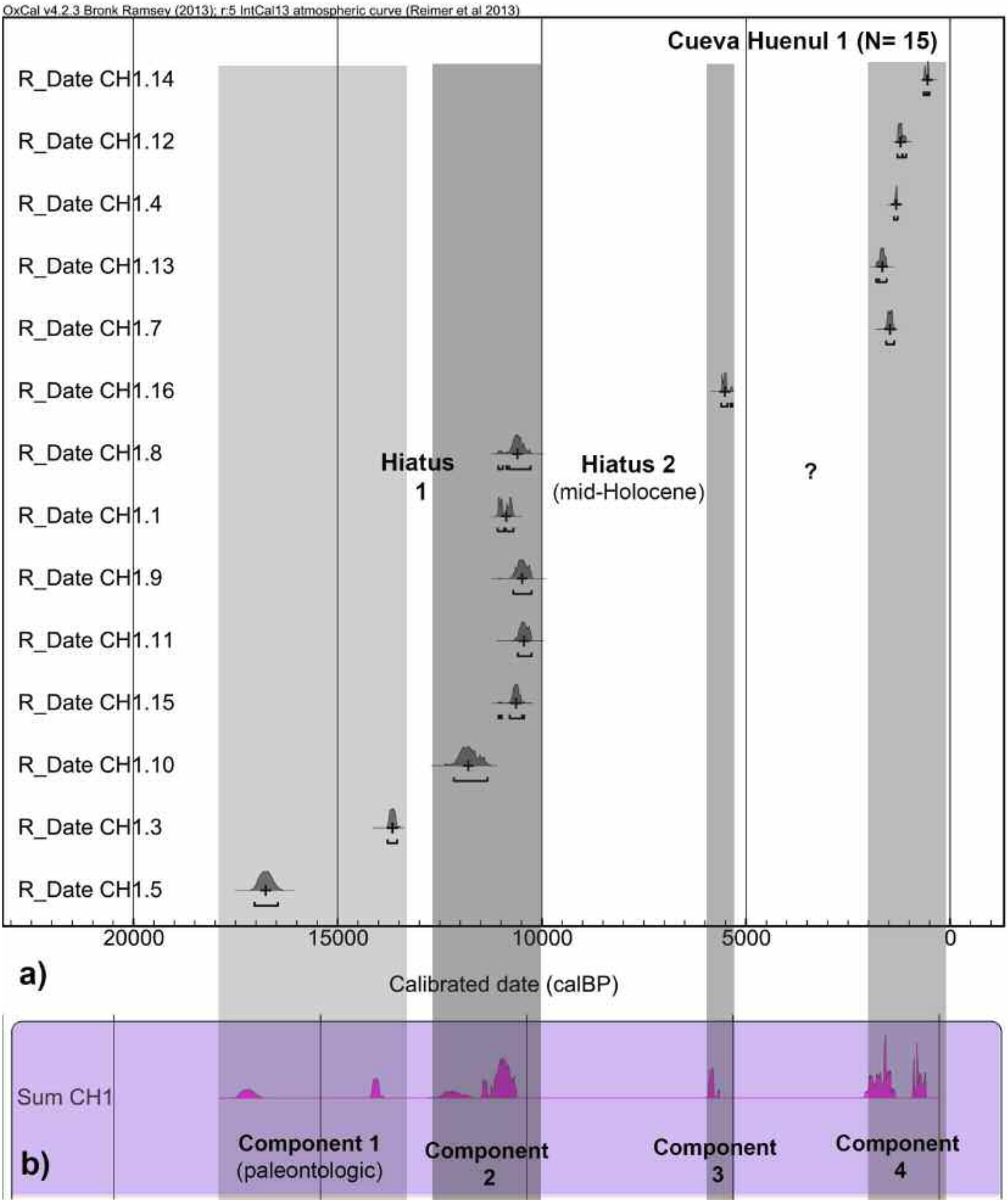

Figure 5. Distribution of dates from CH1: (a) Individual dates and components, (b) Sum of probabilities.

have been published elsewhere (Barberena et al. 2015a; Fernández et al. 2012; Llano and Barberena 2013; Rughini and Pompei 2014). A taphonomic study indicates that predatory birds deposited the micro-faunal assemblages (Fernández et al. 2012), whereas macro-faunal and macrobotanical assemblages have a clear human signature (Llano and Barberena 2013). Local Huenul obsidian makes up the largest part of the lithic assemblage (Rughini and Pompei 2014), as determined by X-Ray Fluorescence (XRF) and Instrumental Neutron Activation Analysis (INAA) performed on source and artifact samples (Barberena et al. 2011).

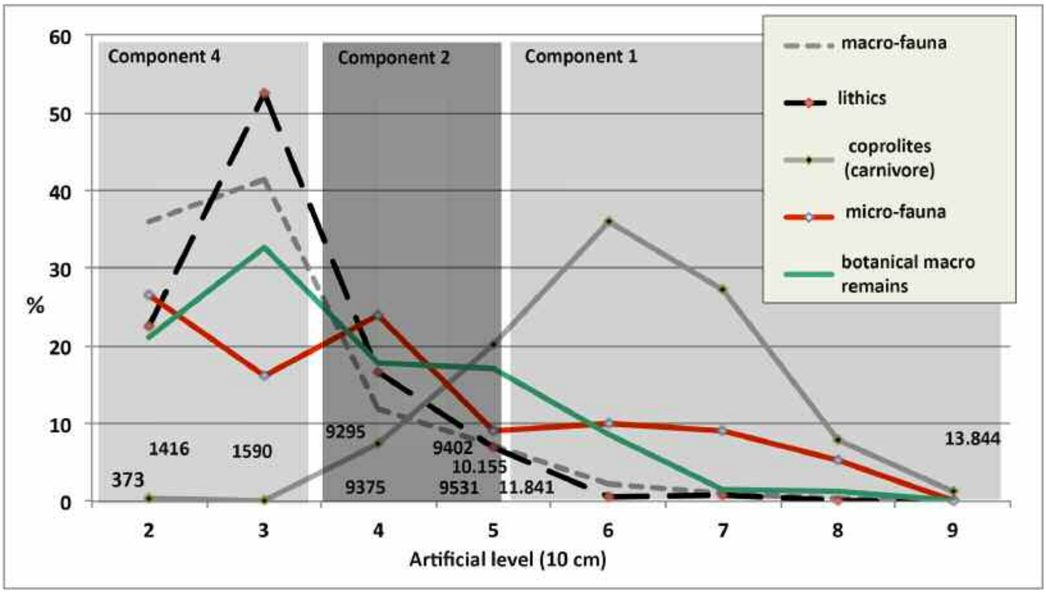

Figure 6. Chronological trends in Quadrat A1 of CH1.

In Levels 6 through 8 of Component 1, there are 19 lithic artifacts (1.3 percent of the total assemblage) that consist of small debitage. Considering that there is evidence of localized disturbance of these layers, we currently interpret this assemblage as having migrated downwards from the Holocene Layers (Rughini and Pompei 2014). There are very few other materials, with the exception of carnivore coprolites, which are most common in the late Pleistocene excavation Level 6 (562 g). There is a negative correlation between the abundance of coprolites and archaeological remains (lithic: $r = -.53$; $p. = .17$; macrofaunal: $r = -.56$; $p. = .14$). Since preservation is better in the upper layers, as observed in the weathering stages of the faunal assemblage, this pattern cannot be explained by differential destruction, suggesting more intensive use of the cave by carnivores when humans were absent from the region.

Component 2 includes Levels 5 and 4, dated between 12,000–10,200 years B.P. A statistical analysis of the dates allows the discrimination of a *minimum number* of two occupations (Figure 5). This component has the first clearly documented human presence in CH1, including two hearths, butchered *Lama guanicoe* (guanaco) bones, and plant remains assigned to *Prosopis* sp. and *Retanilla patagonica* with evidence of human processing for consumption (Llano and Barberena 2013). The lithic assemblage is composed of reduction debris corresponding to the initial (cortical flakes) and final (tool resharpening) stages of reduction. The predominance of late stages of reduction and the absence of tools indicates brief occupations of the site.

Component 4 shows a marked increase in the density of all indicators of human presence. This component is bracketed between the ages of 1600 and 300 cal B.P. in Quadrats A1, C1, and D1 and has a basal date of 1700 cal B.P. in test pit B1. Guanaco dominates the faunal remains, with minor occurrence of other taxa. Resharpening debris is abundant and tool discard rates are very low, indicating that the discard of locally retouched tools predominantly occurred in other contexts. With the exception of projectile points, tools with marginal retouch dominate the assemblage (Rughini and Pompei 2014). This component probably corresponds to the time when abundant rock art was produced on the walls of the cave (Romero and Re 2014) and a small ceramic assemblage was deposited at CH1.

There is a strong contrast in the density of archaeological materials between Components 2 and 4, suggesting much higher intensity of human occupation during the late Holocene than in earlier times. Nonetheless, despite minor variations, the faunal and lithic assemblages do not change significantly in overall composition. Lithic data show the resharpening of tools that were not discarded at the site itself. This may indicate recurrent but brief episodes of occupation. Furthermore, the frequency or duration of visits, rather than the type of activities that were carried out, could have caused the change recorded between Components 2 and 4. On the other hand, it is likely that the production of rock art became a significant behavior in the late Holocene (Romero and Re 2014). Overall, Huenul obsidian dominates the samples, but Component 4 displays systematic use of high-quality siliceous rocks, locally available in small amounts. These rocks were not used during the early Holocene, probably indicating different stages in accumulation of knowledge about the landscape. The macro-regional distribution of artifacts geochemically sourced to Huenul in the late Holocene indicates its systematic insertion within mobility circuits, although less intensively than alternative obsidian sources located in the Andean highlands (Barberena et al. 2011; Durán et al. 2004; Salgán et al. 2012).

The Human Peopling of Northwestern Patagonia

The Timing of Human Colonization and Local Extinction of Megafauna

CH1 presents a gap of about 1,500 calendar years between the last occurrence of megafauna and the first confirmed human occupation. This is consistent with the majority of findings in northern Patagonia and central-western Argentina (Figure 1). Sites with evidence that humans and megafauna did not overlap in the region include Traful I (Crivelli et al. 1993), Arroyo Malo 3 (Diéguez and Neme 2003), Manqui Malal (Praderio et al. 2012), El Manzano (Neme et al. 2011), and El Chacay (Neme and Gil 2009). In this sense, CH1 provides further solid data substantiating the suggestion that megafauna had disappeared from vast regions of the Andes before initial human colonization (Borrero 2009). This favors an ecological explanation for the retraction of some taxa, such as the ground sloth *Mylodon*, from large parts of their former ranges. Nonetheless, not all cases fit the observed pattern. This indicates regional variation and a likely—although still imprecisely defined—human role in the process in certain regions, particularly those colonized earlier by humans. The cases of Monte Verde II (Dillehay 1997), El Trébol rockshelter (Hajduk et al. 2006), Gruta del Indio (García 2003), and Pilauco (Pino et al. 2013) can be mentioned, with varying degrees of robustness in the associations published.[1]

Though information is limited, a preliminary generalization can be proposed. At the latitude of northwestern Patagonia (ca. 36–41° S), evidence for human-megafauna coexistence is stronger in settings located on the Pacific side of the continent or on its immediately adjacent eastern flanks, as exemplified by the El Trébol site. In contrast, sites located further to the east, in lowland desert contexts, show weak or no evidence for overlap. This could be related to earlier human presence in western regions, later occurrence of megafauna in refugia-like areas, or a combination of both.

Component 2 from CH1 is coeval with the earliest assemblages from sites in northwestern Patagonia, indicating a synchronous pulse at distant places during the Pleistocene-Holocene transition. I suggest that this is compatible with a scenario of human dispersal to marginal regions, such as the northern Patagonian deserts, from previously colonized occupational nodes. As Méndez (2013) argues, there is an important macro-regional gap in the data between Monte Verde II and the other contexts (Figure 7). Interestingly, current information indicates that, excluding some currently unsubstantiated early cases, this hiatus could manifest itself in South America as a whole (see papers in Bueno et al. [2013]). Whether this is due to sampling biases, submerged peri-coastal occupations, or actual demographic discontinuities is currently unknown.

Mid-Holocene Local and Regional Gaps: A Demographic Hypothesis

In CH1, the mid-Holocene is only represented by Feature G from Quadrat D1, dated to 5600–5300 cal B.P. The date for this feature is comparable with ages available for burial contexts in northern Neuquén Province, such as Aquihuecó and Hermanos Lazcano, with initial ages of 4842–4567 and 4200–4000 cal B.P., respectively (Della

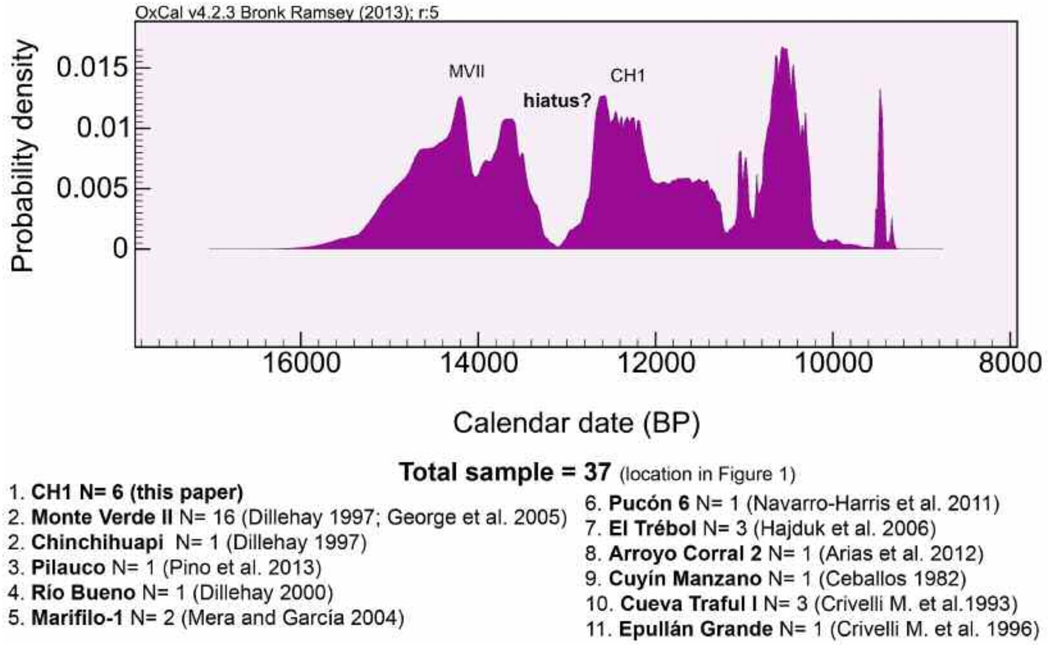

Figure 7. Summed probabilities for early ages (older than 8000 B.P.) in the geographical block between 35–41º S and 73–68º W (sites in Figure 1; data in Barberena et al. 2015b).

Negra et al. 2009; Della Negra and Ibáñez 2012). All these cases correspond to the end of the mid-Holocene. Otherwise, in CH1 this period is subsumed within Hiatus 2, separating the early and late Holocene Components 2 and 4 in Quadrats A1, C1, and D1 (Figure 5). The sequence from Test Pit B1 initiates at 1800 cal B.P. This hiatus is not associated with sterile sediments and could have been produced by erosive processes affecting different sectors of the cave, though it could also reflect occasional human presence and low sedimentation rates during prolonged lapses within this period.

Although intrasite analysis of CH1 requires larger excavations and additional dating, at the regional scale of the South American Arid Diagonal (Figure 1), there is a pattern of low intensity of human presence at varying times between 8000 and 6000 cal B.P. A recent radiocarbon database compiled for northwestern Patagonia shows that the pattern recorded at CH1 has a regional signature encompassing the current dry Monte areas of Neuquén and Río Negro Provinces (Figure 8; Barberena et al. 2015b). Although sampling factors cannot be ruled out as the source for this pattern, I suggest that it reflects a trough in regional human occupational intensity. In doing this, I follow the lead of research in the neighboring region of Cuyo, adjacent to northwestern Patagonia to the north. Neme and Gil (2009) and Méndez et al. (2015) record a sharp decrease in the number of sites, dates, and density of archaeological evidence, linking this with enhanced arid conditions that would have been produced by a latitudinal displacement of the westerly storm-tracks to the south (Lamy et al. 2001).

At an even larger scale, this low-intensity record includes the highland and lowland deserts from Mendoza and San Juan, the Puna region from northwestern Argentina, the Atacama Desert in Chile (Grosjean et al. 2007; Méndez et al. 2015; Neme and Gil 2009; Yacobaccio 2013), and possibly the Argentine Pampas (Barrientos and Pérez 2005; cf. Martínez et al. 2015). Persistent arid conditions would have produced an increasing process of landscape fragmentation affecting desert areas in particular, with the effect of nucleating human groups in suitable refugia proposed for different loci. Parts of the Andean highlands (Méndez et al. 2015), the western Patagonian mesic steppes in Neuquén (Barberena et al. 2015b), and the Laguna Tagua Tagua region in Central Chile (Jackson et

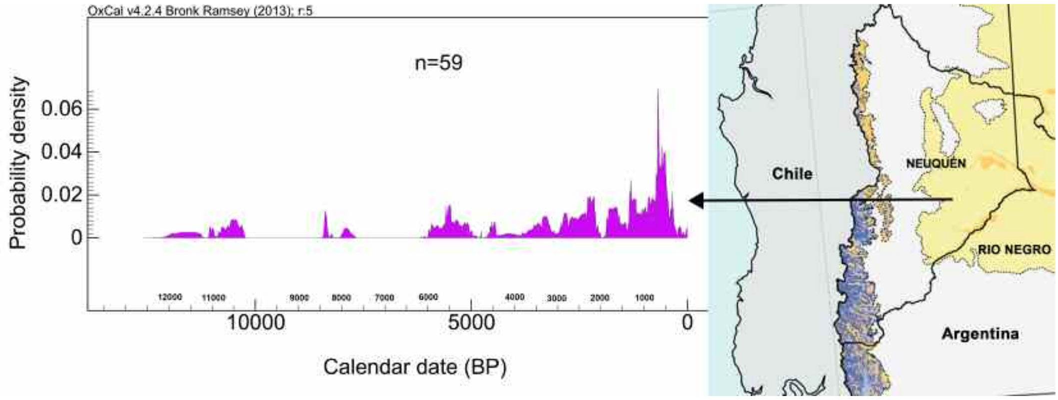

Figure 8. Summed probabilities for sites located in the Monte Deserts of Neuquén and Río Negro Provinces (see data in Barberena et al. 2015b).

al. 2012) could have functioned as refugia. Notably, some of these localities present unusual mid-Holocene burial contexts (Fernández 1988–1990; Kaltwasser et al. 1983).

The primary human response to landscape fragmentation would have been spatial and organizational rearrangements (Garvey 2008). There are limits, however, to the capacity of these mechanisms to overcome landscape fragmentation. The key issue is the extent of landscape fragmentation, or the amount of space that may have become barriers for humans (Barberena 2014b; Smith 2013; Veth 1993). Moreover, the demographic conditions in refugia in advance of fragmentation would have set a limit on their capacity to incorporate incoming people. Competition, technological innovation, and new modes of subsistence could have arisen as a result of this process. I suggest here that the macro-regional evidence, fragmentary as it is, indicates the need to consider a scenario involving other processes in addition to spatial rearrangement.

If we can substantiate the claim of lower overall demographic levels (as would suggest a sum of local occupational histories) coupled with contractions in range (as indicated by a large number of regions with low to no evidence for occupation), then there is a basis to suggest that population bottlenecks may have occurred (Bennett and Provan 2008). This hypothesis provides an explicit demographic scenario at a large spatial scale, building upon previous suggestions at smaller scales (Grosjean et al. 2007; Neme and Gil 2009). Importantly, the bottleneck scenario also provides a *release* or demographic expansion stage following the trough (Ambrose 1998, 2003; Mielke and Fix 2007), which may explain several demographic, economic, and social processes observed after 6000 cal B.P. As already suggested, experiments with intensification leading to camelid domestication in the Andes may be part of this process (Yacobaccio and Vila 2013; see also Mengoni and Yacobaccio 2006).

We currently lack appropriate evidence to disentangle the weight of spatial, organizational, and demographic mechanisms during this period, although we must assess their long-term consequences for human societies. This hypothesis adds an explicitly demographic component to previous suggestions (see Barrientos and Pérez 2005) and should be assessed by different means, chiefly radiocarbon records from multiple regions (Barberena et al. 2015b; Méndez et al. 2015) and genetic information. We should aim at a continental assessment of desert expansion and of the structure of the mid-Holocene archaeological record. This would be the appropriate scale to move analysis from local histories of occupational intensity to large-scale demographic processes, disentangling spatial rearrangements from actual changes in population size.

Perspectives

I have explored the relevance of a remarkable local chrono-stratigraphic sequence for assessing large-scale historical processes. The first part of the discussion was centered on assessing the chronology of initial human presence and the last occurrences of megafauna at the local and regional scales. The data presented here and most of the other cases available indicate no coexistence and a minor human role in the extinction of megafauna, favoring ecological causes instead. There is a gap of 1,000 calendar years between the first record of human presence in South America (i.e., Monte Verde) and evidence for human occupation in the inland Patagonian deserts. I suggest that this could have been the result of a lag implied in the dispersion to marginal regions of South America from the early demographic nodes. Spatial and demographic aspects of this period remain largely unknown.

I have also explored large-scale socio-demographic processes during segments of the mid-Holocene and suggested that this trough reflects not only spatial and social rearrangements, but also a macro-regional population retraction. This could have produced a genetic bottleneck and, if correct, would require rethinking aspects of the mid-Holocene demographic dynamics in South American deserts. I also suggest the existence of a release stage of demographic expansion occurring in post mid-Holocene times.

The spatial structure of refugia and their demographic meaning are outstanding topics for intercontinental comparison (Barberena 2014b; Smith 2013; Williams et al. 2013). Depending on their duration and intensity, bottlenecks are hard to grasp at archaeological scale (Ambrose 1998), even when based on genetic evidence (Rogers and Jorde 1995). Nevertheless, they could have had important long-term consequences at biological and cultural levels that we need to start modeling and testing. Besides augmenting the South American database, this contribution highlights the relevance of local data for reassessing large-scale processes and suggesting new scenarios and questions. These preliminary inferences complement our biogeographic modeling of the late Holocene occupation of northwestern Patagonia (Barberena 2013). Moreover, they contribute to sketching the changing role of the region within the wider sequence of historical events in South America.

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Note

1. In the case of Pilauco, it was decided to use only the age from charcoal that "dates a lens with high concentration of large pieces of charcoal in PB-9" (Pino et al. 2013:6). This is a conservative decision until a stronger case is made for the anthropic deposition of the faunal remains. The latter have an uncertain taphonomic history, as well as the oldest ages within the sequence.

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