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Early Horizon Camelid Management Practices in the Nepeña Valley, North-Central Coast of Peru

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Abstract

South American camelids (llamas and alpacas) were of great economic, social, and ritual significance in the prehispanic Andes. Although these animals are largely limited to high altitude (>3,500 masl) pastures, it has been hypothesized that camelids were also raised at lower altitudes in the arid coastal river valleys. Previous isotopic studies of Early Intermediate Period (c. 200 BC to AD 600) and Middle Horizon (c. AD 600 to 1100) camelids support this argument. Here, we utilize carbon and nitrogen isotopic analyses of camelid bone collagen from the Early Horizon (c. 800 to 200 BC) sites of Caylán and Huambacho on the north-central coast of Peru to examine the management of these animals during the first millennium BC. Most of the camelid isotopic compositions are consistent with the acquisition of animals that were part of caravans, moving between the coast and the highlands. A small number of the animals may have been raised on the coast, suggesting that the practice of coastal camelid husbandry was in the experimental phase during the Early Horizon before growing into a more established practice in the Early Intermediate Period. These results echo zooarchaeological studies from the region that have revealed a paucity of camelid remains in refuse deposits prior to 800 BC, followed by an increase in abundance after 450 BC.

Keywords: Stable isotopes; Carbon; Nitrogen; Animal husbandry; Andes; Llama; Caravan; Exchange
Introduction

In the Americas, the South American camelids (llama \textit{Lama glama} and alpaca \textit{Vicugna pacos}) were the only large mammalian species to be domesticated. While there was temporal and regional variability, these animals were utilized for their meat (Pozorski 1979a; Miller and Burger 1995; Marcus et al. 1999), wool (Murra 1962; Boytner 2004; Millaire 2008), dung (for fuel and fertilizer) (Winterhalder et al. 1974; Grossman 1983; Bruno 2014), and as pack animals (Browman 1975; Stahl 1988; deFrance 2010). Camelids figured prominently in iconographic representations (Shimada and Shimada 1985; Stone-Miller 1992) and ceremonial events (Donnan and Foote 1978; Millaire 2002; Goepfert 2012; Szpak et al. 2014; Millaire 2015; Szpak et al. In Press). They permeated every aspect of life in the pre-Hispanic Andes and were thus intimately intertwined with political, religious, and social developments in the region. Accordingly, understanding camelid management practices, as well as the interactions between people and these animals is critical in the context of Andean prehistory.

After the arrival of the Spanish in the sixteenth century various aspects of camelid management were recorded (Murra 1965, 1968, 1980). Yet, many questions remain surrounding the broader applicability of these models across both time and space. Overall, animal management practices prior to the Late Horizon (A.D. 1476 to 1532) are particularly poorly understood. This is due largely to the fact that traditional agro-pastoral systems were severely disrupted by the Spanish conquest in the sixteenth century (Gade 1992). Moreover, the number of camelids, as well as their range was substantially reduced and, in many places, European domesticates (pig, sheep, and donkey) began to overshadow camelids in terms of economic importance (Wheeler 1995).
On the basis of ethnographic and ethnohistoric accounts, camelid herding was principally associated with the high altitude (>3,500 masl) pastures of the *altiplano* and *puna* (Gilmore 1950; Murra 1962, 1965, 1968; Browman 1974; Winterhalder *et al.* 1974; Orlove 1977b; Flores-Ochoa 1979; Murra 1980; Orlove 1982; McCorkle 1987; Flannery *et al.* 1989; Browman 1990a, b; Kuznar 1991). This is the environment in which camelid pastoralism originated (Wheeler 1985; Browman 1989; Kuznar 1989; Moore 1989; Wheeler 1995; Aldenderfer 2001) and the nature of management in the highlands has been widely examined in archaeological contexts (Browman 1984; Moore 1988; Webster 1993; Moore *et al.* 1999; Duncan 2003; Webster and Janusek 2003; Aldenderfer 2006; Beaule 2012; Knudson *et al.* 2012; Vallières 2012). Camelids are, however, regularly present in refuse and ceremonial deposits at sites on the north, central, and south coasts of Peru from at least the Early Horizon (c. 800 BC) and through to the Late Horizon (c. AD 1476 to 1532) (Pozorski 1979a; Pozorski 1979b; Reitz 1979; Shimada and Shimada 1985; Marcus *et al.* 1999; Bonavia 2008; Chicoine 2011; Goepfert 2012; Millaire 2015). Some scholars have argued that camelids (specifically llamas) were raised locally along the coast, rather than being imported from higher altitudes either as dried meat (*ch’arki* or jerky) or meat on the hoof via coast-highland networks of llama caravans. In the most comprehensive summary of various lines of evidence for coastal camelid herding, Shimada and Shimada (1985) argued that this practice was established by the onset of the Middle Horizon (c. AD 600) on the north coast of Peru and suggested it may have started as early as the Early Horizon (c. 800 BC). With the exception of neonates, however, the presence of camelid remains at coastal sites can be difficult to interpret as unambiguous evidence for local herding. Hence, the presence of camelid skeletal remains on the coast alone cannot be used as definite indicator of local herding.
Because of the large environmental and phytogeographic differences between the coastal and high altitude regions of Peru and associated differences in plant isotopic compositions (Szpak et al. 2013), stable isotope analyses have been employed to assess the question of camelid husbandry outside the highlands (DeNiro 1988; Verano and DeNiro 1993; Thornton et al. 2011; Dufour et al. 2014; Szpak et al. 2014; Szpak et al. 2015; Szpak et al. In Press).

Generally, a pattern emerges in which animals recovered from coastal contexts are characterized by significantly higher dietary contributions of C4 plants (likely maize) relative to camelids from the highlands, as well as greater inter-individual isotopic variability. This pattern is clearly manifested at several sites on the north coast of Peru during the Early Intermediate Period (beginning c. 200 BC), which strongly suggests coastal based camelid husbandry by this time (Dufour et al. 2014; Szpak et al. 2014; Szpak et al. In Press). It is, however, unclear whether or not coastal camelid husbandry predates the EIP and the emergence of what have been characterized as archaic states on the north coast of Peru (Fogel 1993; Millaire 2010; Chapdelaine 2011). Presently, the only pre-EIP isotopic data that exist for coastal camelids come from three individuals from La Paloma (5800–1800 BP) on the southern central coast of Peru (DeNiro 1988) but their precise context is not clear. The purpose of this study is to analyze the isotopic compositions of camelid bone collagen from Caylán and Huambacho, two Early Horizon settlements located in the coastal portion of the Nepeña Valley to assess whether or not the previously observed isotopic patterns of coastal camelid management can be traced back to the first millennium BC.

Isotopic Context
The western slope of the Peruvian Andes is a region of marked environmental variation. As altitude increases moving from the arid coastal desert, mean daily temperature decreases and mean annual precipitation increases (Troll 1968; Sandweiss and Richardson 2008). Consequently, the carbon and nitrogen isotopic compositions of vegetation vary in accordance with altitude, and the low (coastal) and high altitude regions are isotopically distinct (Szpak et al. 2013). This is true in terms of wild plants and to a lesser extent for domestic plants. On the coast and at low altitudes, where conditions are relatively warm and dry, C₄ plants occur regularly. The high altitude habitats associated with modern camelid herding are generally devoid of C₄ species, with the exception of *Muhlenbergia* sp., which has been recorded in some highland pastures. Nevertheless, these plants are not especially abundant (Wilcox et al. 1987) and constitute a relatively minor fraction (no more than 15% and usually much less) of camelid forage today (Bryant and Farfan 1984; Reiner and Bryant 1986).

On the basis of the isotopic ecology of the western slope of the Andes (Szpak et al. 2013), as well as previous isotopic studies of camelids, we can generate a series of expectations with respect to camelid isotopic compositions to assess whether or not they were herded in a particular ecological zone, which are summarized in Figure 1. These approximations are intended to represent isotopic data derived from bone collagen, which continuously turns over and therefore represents an average of the long-term diet (Wild et al. 2000). As with nearly all species, controlled studies examining the turnover rates of bone collagen in camelids have not been performed. Based on estimates of turnover rates in human bone collagen (upwards of 20 years; Stenhouse and Baxter 1979; Wild et al. 2000; Hedges et al. 2007), however, it is reasonable to assume that the isotopic composition of camelid bone collagen reflects a lifetime average of diet. Therefore, collagen lacks the ability to resolve more precise life histories relative
to tissues that grow continuously such as hair (Szpak et al. 2014) or tissues that may be sampled along growth axes such as teeth (Dufour et al. 2014).

For camelids herded on the high altitude pastures of the puna and altiplano, we expect low carbon isotopic compositions, consistent with diets composed principally (>80%) of C$_3$ plants. Nitrogen isotopic compositions are relatively difficult to predict because the pastures on which camelids graze in the Andean highlands may be relatively wet (e.g., the bofedales [cushion-peat bogs] and moist punas that occur in the central Peruvian highlands) or dry (e.g., the dry and salt punas that occur primarily in southern Peru and further south, east of the Atacama) (Baied and Wheeler 1993). Given that plant tissue $\delta^{15}$N values tend to be higher in under conditions of limited water availability (Handley et al. 1999; Amundson et al. 2003; Craine et al. 2009), we would expect high $\delta^{15}$N values in dry relative to moist highland pastures, although this requires experimental verification.

While comparatively few modern camelids from high altitude contexts (both modern and archaeological) have been subjected to isotopic analysis, none have been characterized by the high (>8‰) nitrogen isotopic compositions that have been recorded for some camelids from coastal and low altitude sites (DeNiro 1988; Verano and DeNiro 1993; Thornton et al. 2011; Dufour et al. 2014; Szpak et al. 2014; Szpak et al. 2015). A pattern of camelid diets dominated by C$_3$ plants has been recorded for modern camelids from high altitude contexts throughout much of Peru (Schoeninger and DeNiro 1984; Thornton et al. 2011; Dufour et al. 2014; Szpak et al. 2014), as well as archaeological camelids from Chinchawas (3,850 masl) (Szpak et al. 2015) and Tiwanaku (3,800 masl) (Szpak 2013). For camelids that were herded on the coast, we predict three different patterns depending on whether the principle forage was agricultural fodder (e.g.,
maize and other byproducts) or wild plants, and the scale at which herding was practiced (large or small herds).

For camelids herded on the coast or at low altitudes that grazed on wild vegetation, we expect high carbon isotopic compositions (due to a higher proportion of C_4 plants in the diet) and much higher nitrogen isotopic compositions (due to the consumption of vegetation growing under water-limited conditions) relative to high altitude camelids. Because the coastal and low altitude regions still contain appreciable quantities of C_3 plants, relatively low carbon isotopic compositions are still feasible, although most of these plants should still be characterized by high nitrogen isotopic compositions because of the aridity effects on vegetation (Szpak et al. 2013).

These patterns have been observed in camelids from several sites, although not necessarily interpreted in this manner: Cerro Baul in the Moquegua Valley (2,500 masl) (Thornton et al. 2011), as well as Chilca and La Paloma on the southern central coast of Peru (DeNiro 1988).

The coast of Peru is essentially a desert environment with areas of herbaceous vegetation being more common in coastal river valleys, which today may support small numbers of grazing goats in some areas (Rundel et al. 1991). The lack of substantial vegetation on the coast is, however, a potential limitation to the herding of camelids. Accordingly, it has been suggested that coastal camelids would have been provided with principally, or entirely, fodder from agricultural products or byproducts. This is an important distinction in terms of animal management practices, and the consumption of coastal cultigens should manifest itself differently in camelid tissue isotopic compositions relative to the consumption of wild coastal vegetation.

On the coast of Peru rainfall occurs only under exceptional circumstances and agriculture is entirely dependent on irrigation (Rauh 1985). Because of this, cultigens are not subjected to
the water-limited conditions characteristic of wild coastal vegetation and the influence of local
environmental conditions on plant δ^{15}N values is mediated (Szpak et al. 2012a). Therefore,
coastal camelids provided with agricultural fodder will not be characterized by unusually high
δ^{15}N values. Nevertheless, C_{4} cultigens are much more common at lower altitude and coastal
sites relative to those in traditional camelid herding areas, which instead focus on tuber (all of
which are C_{3} plants) cultivation (Orlove and Godoy 1986). Therefore, unlike low altitude
camelids grazing on wild vegetation, coastal camelids foddered with agricultural byproducts
should be characterized by relatively high, but variable, carbon isotopic compositions (due to the
importance of maize foddering), but nitrogen isotopic compositions that are comparable to
camelids herded in highland pastures. Such a pattern has been observed at many sites along the
north coast of Peru including Huaca Gallinazo, Huaca Santa Clara, and Huancaco in the Virú
Valley (Szpak et al. 2014), Pacatnamú in the Jequetpeque Valley (Verano and DeNiro 1993),
and El Brujo in the Chicama Valley (Dufour et al. 2014). It is important to point out that the
sample sizes for the latter two sites were quite small, making it difficult to formulate any broad
generalizations about camelid diets.

A third pattern involves intensive foddering of camelids with maize. In this case,
camelids are still fed agricultural products or byproducts but consume a markedly less varied diet
at the group or population level and would be characterized by consistently high δ^{13}C values.
Evidence for intensive maize foddering has been recorded at Conchopata (2,700 masl) where
several camelids (interpreted to be llamas) had δ^{13}C values of c. −10 ‰ (Finucane et al. 2006).
This pattern is not necessarily specific to any particular region, but the fact that maize is not
cultivable above c. 3,500 masl (Sandweiss and Richardson 2008) and C_{4} plants are also sparsely
distributed above this altitude (Szpak et al. 2013) precludes this camelid management strategy
from the puna. To date Conchopata is the only site where these isotopic compositions have been observed, although it is important to note that the $\delta^{13}C$ values were bimodally distributed and it is unclear whether a larger sample from the site would have obscured this pattern and produced a dataset more similar to others from sierra and coastal sites.

Archaeological Context and Materials

Nepeña is a small coastal oasis located 400 km north of Lima (Figure 2). The valley is perhaps most famous for its strong human presence and dynamic cultural innovations during the first millennium BC (Proulx 1982; Daggett 1983, 1984). During the local Nepeña Phase (800-450 cal BC, Figure 3) (see Shibata 2011), late Initial Period ceremonial centers such as Cerro Blanco and Huaca Partida were abandoned and populations gradually nucleated at urban-like settlements on the north and south margins of the valley. Survey and excavation work over the last decade indicate that these developments were associated with the rise of an Early Horizon polity based at the primary center of Caylán, the largest archaeological complex in Nepeña (Chicoine and Ikehara 2010, 2014).

Caylán is located on the northern margin of the lower valley, some 15 km from the Pacific coastline. The site appears strategically located at the center of the catchment area of the lower valley polity. Meanwhile, secondary satellite communities in the lower valley have been recorded at Huambacho (Chicoine 2006), Sute Bajo (Cotrina et al. 2013), Samanco (Helmer and Chicoine In Press), and perhaps Cerro Blanco (Shibata 2010, 2011). Radiocarbon dates indicate that the polity reached its climax during the local Samanco Phase (450-150 BC), before giving way to outside influences at the turn of the first millennium AD (Chicoine 2011).
Combined with settlement pattern data, the analysis of faunal and botanical remains from secure excavated contexts at Cerro Blanco (Ikehara et al. 2013), Huambacho (Chicoine 2011; Chicoine and Rojas 2012), and Caylán (Chicoine and Rojas 2013; Chicoine et al. In Press) have provided insight into the profound socioeconomic transformations experienced by Early Horizon groups in coastal Nepeña. Most salient among these transformations are the extension of irrigation networks, the intensification of maize cultivation, and the increased reliance on highland animal domesticates – namely guinea pigs and camelids. Previous research suggests that these innovations were closely tied to a reorganization of exchange networks, shifts in leadership strategies, heightened elite competition as materialized in the acquisition of prestige items, the construction of more exclusive ritual settings, and the sponsoring of feasts and alcohol production (Chicoine 2011; Ikehara et al. 2013). While camelids and their use as caravan animals likely played a crucial role in the realignment of political and economic strategies during the Nepeña and Samanco phases, little is currently known about the actual movements of these animals and their management.

Between 2003 and 2010, Chicoine directed a combined 39 weeks of fieldwork at Huambacho and Caylán to investigate Early Horizon cultural developments in coastal Nepeña. Mapping and excavation results from Caylán indicate that the Early Horizon settlement was organized into more than 40 monumental house compounds agglutinated into a dense urban core and articulated through a complex network of streets and alleyways. Excavations sampled more than 560 m² and yielded information on different types of primary and secondary discard contexts including floor scatters, open air middens, and construction fills (Figure 4). A total of six excavation areas (UE1-6), and sixteen test units (HP1-16) were excavated, along with the clearing of a looter’s pit (PH1). Overall, the excavated contexts and associated structures and
materials allow for a preliminary consideration of (1) a monumental platform complex (Main Mound Complex, UE1, 4), (2) a public space (Plaza-A, UE2, 5), (3) a multi-functional residence (Compound-E, UE6), and (4) several other discard areas located throughout the site and sampled through UE3, the test pits (HP), and PH1. The samples of camelid remains analyzed in this article come the Main Mound Complex (n=8), Plaza-A and one of its adjacent patios (n=6), the residential portion of Compound-E (n=5), as well as peripheral open-air middens (n=3). Overall, the samples from Caylán appear to correspond to discard episodes associated with the ceremonial use of plaza and mound spaces (Main Mound, Plaza-A), the more domestic or daily consumption of camelids (Compound-E), as well as the secondary transport of skeletal remains away from the urban core. Stylistic evidence and radiocarbon measurements suggest that all the sectors sampled were occupied contemporaneously.

Meanwhile, excavations at Huambacho sampled more than 4,500 m² and yielded insights into the occupation of a small elite center located on the southern margin of the coastal plain, some 8 km from the shoreline. Here, materials mainly came from the clearing of plazas and patio halls associated with feasting practices and ceremonial gatherings. More specifically, the camelid remains analyzed in this study are associated with the use of a monumental plaza (Plaza-B, n=1), as well as a small mound complex interpreted as an elite residence (Huaca-A, n=2). Radiocarbon measurements securely place the excavated contexts at Caylán and Huambacho within the Early Horizon (Chicoine 2010a; Chicoine and Ikehara 2010, 2014).

The excellent organic preservation at both sites allowed the recovery of a rich faunal assemblage. Taxonomic analyses of the vertebrate remains indicate that the dwellers of these two Early Horizon settlements interacted with, used, ate, and processed a vast array terrestrial, marine, riverine, and lacustrine vertebrates including amphibians, reptiles, fish, birds, and
mammals. The role of camelids was likely diverse, serving as pack animals, sources of meat and bones, and perhaps fibers. Yet, solid conclusions about local herding practices remain out of reach since no corrals, dung, or other indications of in situ husbandry were detected at Caylán or Huambacho. It is significant, however, that recent fieldwork at Samanco, an Early Horizon site located 2 km from the coast on the northern margin of the lower Nepeña, revealed a series of rectangular rooms with large amounts of compacted camelid dung (Helmer and Chicoine In Press). With a surface area of more than 800 m², the structure could have easily housed up to 200 llamas, possibly more. More research is needed on the Samanco assemblage, but it appears possible that llama caravans were travelling to the coastal center to move marine resources. Differences, for instance, in the composition of the shell assemblages from Samanco and Caylán suggest that a limited number of select bivalve species supplied inland populations, in particular the small intertidal clam Donax spp. (Chicoine and Rojas 2013). In contrast, deposits at coastal settlements contain a richer and more diverse corpus (Matthew Helmer, personal communication 2014).

Nineteen camelids from Caylán and three from Huambacho were sampled for stable isotope analysis (Table 1). The vast majority of the samples consisted of first phalanges, as well as three astragali (although these failed to produce acceptable collagen and are not included in the analysis) and a single mandible (Table 1). The same non-repetitive elements were sampled from each context (i.e. Main Mound, Plaza-A, Compound-E at Caylán) to avoid sampling the same individual. Based on the epiphyseal fusion data provided in Kent (1982), the animals sampled were all >2 years of age.

Methods
Because it is exceptionally difficult and in most cases impossible to accurately
differentiate South American camelid species on the basis of postcranial skeletal elements
(Shimada 1982), the samples analyzed in this study could only be identified as camelids and not
to any particular species. Based on limited osteometric analyses conducted on camelids
recovered from Early Horizon contexts, these individuals are more similar to modern llamas than
they are to alpacas (Vásquez and Rosales 2012).

Bone collagen was extracted using previously described methods (Szpak et al. 2014).
Isotopic and elemental compositions ($\delta^{13}C$, $\delta^{15}N$, % C, % N) were determined using a Thermo
Finnigan Delta V continuous flow mass spectrometer coupled to a Costech Elemental Analyzer
at the Laboratory for Stable Isotope Science (University of Western Ontario). Carbon and
nitrogen isotopic compositions were calibrated to VPDB and AIR with USGS40 (glutamic acid,
accepted values $\delta^{13}C = -26.39\,^{\circ}$‰, $\delta^{15}N = -4.52\,^{\circ}$‰) and USGS41 (glutamic acid, accepted
values $\delta^{13}C = 37.63\,^{\circ}$‰, $\delta^{15}N = 47.6\,^{\circ}$‰). Details on analytical accuracy and precision are
summarized in the Supplementary Material.

All statistical analyses were performed with the open source statistical package R (R
Development Core Team 2007) for Mac OS X. Relative contributions of C$_3$ and C$_4$ plants were
quantified using a single isotope Bayesian mixing model with the SIAR package (Parnell et al.
2010). The following parameters were used in the mixing model:

Sources: C$_3$ plants ($-26.12\pm1.75\,^{\circ}$‰) and C$_4$ plants ($-12.01\pm0.95\,^{\circ}$‰). These values represent
means ± one standard deviation of wild and cultivated plants sampled in northern Peru (Szpak et
al. 2012a). The values presented above have been adjusted by +1.50 \% to account for the Suess
Effect (Yakir 2011).
Corrections: Trophic level fractionation for bone collagen was obtained from a survey of published literature (Szpak et al. 2012b): $\delta^{13}C_{\text{collagen-diet}} = +3.6\pm1.7\%$.

Results

Isotopic and elemental compositions for all specimens analyzed are presented in Table 1. Nineteen of the twenty-two specimens from which collagen was extracted produced atomic C:N ratios within the range of accepted values for well-preserved bone collagen (2.9–3.6) as reported by DeNiro (1985). For the 19 samples with acceptable C:N ratios, collagen yields were >1%, while the 3 samples with unacceptable C:N ratios were also characterized by collagen yields <1% (AIS−1299, AIS−1313, AIS−1314). Accordingly, results for these three samples have been omitted from all summary statistics, plots, and analyses (Ambrose 1990).

Individual carbon and nitrogen isotopic compositions for the Nepeña camelids are plotted in Figure 5A and Figure 5B. These data are overlain atop heat plots generated on the basis of isotopic datasets for camelids from coastal archaeological sites ($n=160$) and highland archaeological sites as well as modern highland (>3,200 masl) camelids ($n=155$) (compiled by Szpak 2013). The majority (16/19) of the Nepeña camelids (those with $\delta^{13}C$ values <−16‰) fit generally with the isotopic compositions of high altitude camelids, although three individuals from Caylán (those with $\delta^{13}C$ values >−16‰) have isotopic compositions inconsistent with high altitude pasturing.

The results of the two-source ($C_3/C_4$) Bayesian mixing model (SIAR) are presented in Figure 6. Two comparative camelid datasets are also presented in: a group of Middle Horizon camelids from a high altitude herding site (Chinchawas in the Callejón de Huaylas) and a group of Early Intermediate Period camelids from a coastal site (Huaca Gallinazo in the Virú Valley).
(Szpak et al. 2014; Szpak et al. 2015). On the basis of a growing body of isotopic measurements of camelids from coastal, highland, and intermediate altitudes in Peru (DeNiro 1988; Verano and DeNiro 1993; Finucane et al. 2006; Thornton et al. 2011; Szpak 2013; Dufour et al. 2014; Szpak et al. 2014; Szpak et al. 2015; Szpak et al. In Press), the two comparative datasets presented in Figure 6 are the largest and are representative of typical coastal and highland patterns.

Collectively, the Caylán camelids are characterized by intermediate carbon isotopic compositions relative to the comparative groups from the coast (Huaca Gallinazo) and highlands (Chinchawas). These comparisons do not take into account any intragroup complexities that may drive these patterns, which is somewhat problematic. The majority of the Caylán camelids have $\delta^{13}$C values between $-20$ and $-16$‰ and a panel is included in Figure 6 that removes the three individuals with $\delta^{13}$C values greater than $-16$‰. Even after removing these three values, the Caylán camelids still have diets consistent with significantly greater $C_4$ plant consumption than the Chinchawas (highland) camelids ($p<0.001$) suggesting some differences in camelid life histories between the two groups. Therefore, neither the coastal pattern of diversified camelid husbandry involving significant $C_4$ plant foddering (Szpak et al. 2014), the specialized urban pattern of almost exclusively maize foddering (Finucane et al. 2006), nor the highland pattern of pasturing (as is seen in the Chinchawas data) adequately characterizes the Caylán camelids.

**Discussion**

We posit that the isotopic data for the Caylán camelids are reflective of two economic strategies. The first involves the acquisition of camelid livestock traded in from higher altitude zones. These animals were likely born in the highlands and moved to the coast at some point in their lives prior to being killed and consumed. They may have been animals associated with or
part of caravans that moved to and from the coast, consuming a more mixed C_3/C_4 diet than
those animals living exclusively on the high altitude pastures of the puna, with maize fodder
being provided to the animals at various points along the way, possibly in exchange for goods
being moved by the caravans – this practice was recorded in ethnohistoric accounts (e.g. Zárate
1555).

While we cannot definitely rule out that the camelids with relatively low δ^{13}C values
were not foddered with local C_3 forage – the practice of feeding camelids with the beans and
pods of the algarrobo tree (*Prosopis* sp., a N_2-fixing C_3 species common in coastal Peru) has
been observed in coprolites from coastal Late Intermediate Period specimens (Shimada and
Shimada 1985) – this explanation seems unlikely given that this pattern (at the site level) has not
been observed in over 200 camelid C and N isotopic measurements from 12 other coastal sites
(DeNiro 1988; Verano and DeNiro 1993; Szpak 2013; Szpak *et al.* 2014; Szpak *et al.* In Press).
Moreover, there is limited additional evidence supporting local camelid husbandry, such as the
presence of structures resembling corrals or the accumulation of significant quantities of dung
(for examples on the coast, see Shimada 1981; Wilson 1988; Szpak *et al.* 2014). This negative
evidence has to be interpreted with caution, but the fact remains that most of the animals have
δ^{13}C values that do not accord well with intensive patterns of local husbandry, but these camelids
were consuming more C_4 plants than would be expected for animals raised in the *puna*. Instead,
we suggest that these camelids were acquired via trade with caravans.

While no isotopic studies have been performed on modern or archaeological animals
known or suspected (in the case of the latter) to have been associated with caravans, modern
observations suggest that caravan animals begin training after two years of age (spending this
time in the *puna*) and consist exclusively of castrated males between 2 and 8 years of age
In the course of their movements, caravan animals graze on locally abundant forage and in some cases are provided with fodder from agricultural products or permitted (sometimes encouraged) to graze field stubble, which typically includes maize at altitudes below 3,500 masl (Browman 1990b).

In southern Peru, modern llama herders often arranged trading trips to the coast at the end of the maize harvest, where animals could have grazed maize stubble intensively, but for a short period of time (Browman 1990a). Thus, animals acquired as adults that were part of caravans would likely show a predominantly C$_3$ diet, particularly if bone remodeling rates are such that the isotopic signature of the collagen disproportionately represents periods of accelerated bone growth early in life (Hedges et al. 2007), when the animals were still living in the puna.

Interestingly, there is a strong positive correlation between $\delta^{13}$C and $\delta^{15}$N values for the Nepeña camelids consuming predominantly C$_3$ plants (Spearman’s $\rho$=0.76, p<0.001), suggesting that the C$_4$ plants consumed by these camelids had significantly higher $\delta^{15}$N values than the C$_3$ plants they consumed.

By way of comparison, the camelids from the high altitude herding site of Chinchawas (Szpak et al. 2015) show a negative, but not statistically significant correlation between bone collagen $\delta^{13}$C and $\delta^{15}$N values (Spearman’s $\rho$=−0.50, p=0.08). These animals are believed to have been alpacas (Lau 2007), and hence would not have been caravan animals moving between altitudinal zones. There are two plausible scenarios for the correlation observed for the Caylán camelids, both of which fit with the consumption of maize from field stubble. They are, however, not mutually exclusive. First, if camelids regularly visited maize plots, they may have deposited significant quantities of dung as they grazed; recent accounts report this activity for modern camelids in agricultural fields after the harvest (McCorkle 1987; Mitchell 1991; Goland...
Indeed, Orlove (1977a) points out the importance of the addition of highland camelid dung for lowland crop growth. The addition of camelid dung to maize fields significantly increases plant tissue $\delta^{15}$N values by between 2 and 4 ‰, even after a single season and at a relatively low rate of application (Szpak et al. 2012a). If caravan camelids consumed this fertilized maize, it would fit with the positive correlation between $\delta^{13}$C and $\delta^{15}$N values observed here for Caylán camelid bone collagen. An additional consideration is the type of plant tissue consumed.

The fact that animals are only permitted to graze on the leaves and stalks in maize fields is significant because there is consistent intraplant $\delta^{15}$N variation in annual crops such as maize. Specifically, leaves and stems have consistently higher $\delta^{15}$N values than grains because of reallocation and resultant discrimination against $^{15}$N that occurs during grain filling; these differences may be on the order of several per mil, and significantly higher (>5 ‰) under conditions of high nitrogen availability, such as occurs with fertilization (Szpak 2014).

Therefore, we would expect animals that had diets consistent with this pattern of seasonal, but relatively limited, fertilized maize leaf and stem consumption to be characterized by carbon and nitrogen isotopic compositions observed for the majority of the Early Horizon camelids.

Although marine fauna are both abundant and diverse at Caylán and Huambacho (Chicoine and Rojas 2012, 2013), camelids are the most abundant vertebrate taxon. At Caylán, they represent 13.3% of the total NISP (n=3,289), and 37.4% of the NISP for mammals (n=1,661). Similarly, at Huambacho, camelids comprise 39.8% of the vertebrate NISP (n=1,300). That most of the camelid remains analyzed have isotopic compositions consistent with a non-local origin suggests that the local population may have relied to a large extent on...
imported camelid meat, which implies a significant level of interaction between coastal and highland communities during the Early Horizon.

During the 1st millennium BC, many transformations can be evoked to account for increased contacts between coastal and highland communities. Technological advances were made, either through innovation or improvement of Initial Period traditions (Burger 1988; Kembel and Rick 2004), however, it is the development of Chavín de Huantar and the spread of the Chavín cult that have traditionally been seen as the main driving forces of change (Keatinge 1981). The Chavín cult was materialized in an iconography centered on images of felines, raptorial birds, caimans, and San Pedro cactus, and expressed the predominance of shamanistic beliefs. It is believed that ideological and religious ties were materialized in similar ritual paraphernalia, iconography, and ceremonial architecture (Burger 1992). In contrast to day-to-day interactions, these interregional interactions existed within the realm of elites.

Some scholars have emphasized the more socioeconomic and political aspects of interregional networks, outlining the limitations of considering the Chavín influence as solely religious (Burger and Matos 2002). They suggest that the circulation of valuables, from the extraction of special materials to the crafting of fine artifacts and the acquisition of non-local goods, primarily answered economic and sociopolitical concerns. From this perspective, groups with privileged access to prized resources and valuables would take advantage of the situation to position themselves within regional networks and increase their power and influence. Burger and Matos (2002) provide an example from the Early Horizon site of Atalla in the central highlands and suggest that the local availability of cinnabar, a mineral valued for its bright red color and used during the Early Horizon in burial rites and for decorating ceremonial objects and buildings, allowed local leaders to gain power. These interactions would have materialized in the
identification of Atalla elites to Chavin precepts and materialized in the emulation of Chavin ceramic styles (Burger and Matos 2002).

In coastal Nepeña, recent research has questioned traditional connections with the Chavin phenomenon and the adjacent highlands (Chicoine 2006, 2010b; Shibata 2010, 2011); especially considering the reevaluation of the occupational history and chronology at Chavin de Huantar (Burger and Salazar-Burger 2008; Rick et al. 2011). While Chavin-related and Cupisnique stylistic features are evident at the late Initial Period ceremonial centers of Cerro Blanco and Huaca Partida, by the time of the emergence of urban communities at Caylán and associated settlements, coastal populations appear to have steered clear of Chavin imagery. Yet, it is precisely during this transition that camelids begin to be common in coastal Ancash. This is likely related to the intensification of bulk exchanges, likely of subsistence goods, along the coast, but perhaps more importantly – based on the results of our isotope study in Nepeña – between the coast and the adjacent highland regions. This suggests that coast-highland interaction networks survived the demise of Chavin-related phenomena, although these were likely substantially reorganized. Here, llama caravans appear to have been important in the transportation of goods between Early Horizon coastal populations and settlements in the more elevated highland regions, likely the Callejón de Huaylas. It is unclear at the moment if these extra-local interaction networks channeled exotic and prestige items, and/or more mundane subsistence staples, but the presence of a camelid corral at the Early Horizon fishing community of Samanco suggests that dried fish and other marine resources were being moved across Ancash. The presence of large amounts of select shell species at inland communities strengthens this assertion (Chicoine and Rojas 2012, 2013).
As mentioned previously, the three Caylán camelids with δ¹³C values higher than −15 ‰ do not fit with the highland mode of pastoralism. Therefore, these individuals merit some additional discussion. There are three reasonable possibilities that might explain the Caylán camelids with relatively high δ¹³C values. First, the local populace was beginning to experiment with camelid herding some time during the Early Horizon and supplied these animals with fodder that included significant quantities of C₄ plants, most likely maize byproducts, but wild local C₄ grass species (e.g., *Distichlis* sp.) may have formed an important part of the diet (Shimada and Shimada 1985). An additional source of wild forage with high δ¹³C values may have been *lomas* (fog oases) located in the Andean foothills. These ephemeral formations occur sporadically throughout the Andes (Ono 1986) and today exist in relatively close proximity to both Caylán and Huambacho in the coastal portion of the Nepeña Valley. Thornton et al. (2011) interpret several individual camelids from Cerro Baúl with relatively high δ¹³C and δ¹⁵N values as possibly having grazed in *lomas* environments.

Second, these camelids may also have been caravan animals that for some reason happened to have consumed significantly higher quantities of C₄ plants than the other individuals despite occupying a similar economic role. Given the limited availability of C₄ plants throughout most of the year at high altitudes, however, this seems unlikely. A more plausible scenario is that these animals were foddered in a way that was distinct from the majority of the Early Horizon coastal camelids because they spent a significant portion of their lives in another location. It is possible that the Caylán camelids with relatively high δ¹³C values may have originated outside of the *puna* pastures above 3,500 masl, but were raised in the intermediate low or high sierra zones (c. 2,300 to 3,500 masl) where maize cultivation still occurs. The high δ¹³C values recorded for the camelids from the Middle Horizon (c. AD 550 to 1000) occupation at
Conchopata, which is located at c. 2,700 masl demonstrate the possibility of camelids being foddered on large amounts of C\textsubscript{4} plants (Finucane et al. 2006), although this is the only instance in which such a pattern has been observed and relevant data are lacking from earlier periods. The C\textsubscript{3} consuming animals at Conchopata have been interpreted to be alpacas that grazed not locally, but in the puna, and the C\textsubscript{4} consuming animals were likely corralled and foddered with maize and/or allowed to graze maize stubble in local agricultural fields (Finucane et al. 2006). This latter pattern of camelid husbandry is very similar to what has been suggested for the north coast during the EIP and Middle Horizon (Dufour et al. 2014; Szpak et al. 2014; Szpak et al. In Press). In other words, while foddering camelids with significant quantities of maize is possible at intermediate altitudes, there is no basis to suggest that it would be any more likely than at low altitudes. There is evidence for corralling and the presence of maize in camelid dung at nearby Samanco in the Nepeña Valley, suggesting local herding of camelids at this site, although the broader regional importance and temporal scale of this activity is presently unclear. That there is some evidence of local corrals and the fact that these animals have isotopic compositions completely inconsistent with high altitude herding (Figure 5A), similarly do not fit with the other Caylán camelids that we have interpreted to be caravan animals. This leads us to hypothesize that people in the lower Nepeña Valley were experimenting with local camelid herding during the Early Horizon. The isotope results suggest dynamic human-animal relationships at the onset of the Early Horizon in which camelids were gradually being brought to and eventually corralled and raised on the coast. This is particularly significant in the context of incipient urban settlements, such as Caylán, where many human groups had the potential to become specialized and detached from primary subsistence activities. Indeed, urban dwellers can acquire meat and other animal products directly or indirectly through state-sponsored and other centralized
systems (Zeder 1991). Traditionally, archaeologists have hypothesized that the development of state-like and other stratified societies led to increasingly efficient and centralized systems of animal management (i.e., increasing number of non-food producers are provisioned by centralized economic/redistributive mechanisms/institutions). In coastal Ancash, it appears that the introduction and increased reliance on camelids as beasts of burdens played a major role in the development of long-distance trade and its associated routes and networks.

That the isotopic data for the Caylán camelids are quite distinct from other coastal sites where husbandry appears much more established (Dufour et al. 2014; Szpak et al. 2014; Szpak et al. In Press) suggests that the activity of local raising camelids was not of great economic importance in Nepeña during the Early Horizon. Herd sizes collectively throughout the valley may have not have been large enough to sustain a local population and the addition of new animals was likely primarily through the acquisition of young animals from highland herds. Shimada and Shimada (1985) posited that llamas were successfully bred and maintained on the north coast of Peru from at least the Middle Horizon (c. AD 600) and possibly dating back to the Early Horizon (c. 200 BC). The results presented here suggest that the experimentation with coastal camelid husbandry through the occasional acquisition of caravan llamas may have begun during the Early Horizon, at least in Ancash, but this hypothesis requires testing through the collection of additional data from other sites, both in Nepeña and along the entire coast, that predate the EIP.

Conclusions

The principal source for camelid consumption at Caylán and Huambacho appears to have been the acquisition of llamas that were likely part of caravans moving between the coast and the
highlands. These animals consumed significant quantities of maize, likely stems and leaves and
probably fertilized maize plots as they grazed, but for relatively short periods of the year. A
small number of camelids from Caylán have isotopic compositions consistent with being raised
locally on the coast, suggesting that the local populace in Nepeña may have been experimenting
with this activity during the Early Horizon. Although the data for Caylan is the third largest
sample of camelids from a single site in Peru produced to date, additional data from
ccontemporaneous sites are necessary before any clear picture of animal management during the
Early Horizon can develop.
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References


Yakir, D. 2011. The paper trail of the $^{13}$C of atmospheric CO$_2$ since the industrial revolution period. Environmental Research Letters 6: 034007.


Figure Captions

Figure 1. (A) Predicted average carbon and nitrogen isotopic compositions (approximating bivariate means with correlation as in the standard ellipse, see Jackson et al. 2011) of four camelids raised under four different foddering regimes. Note that it is not expected that all individuals from a given group will fall into these areas, but that a group of animals foddered under a particular set of conditions will resemble this general pattern. (B) Predicted contribution of C₄ plants for the four camelid groups (WCV=wild coastal vegetation, C₄c=cultivated C₄ crops, MXC=mixed irrigated cultigens, C₃P=C₃ pastures). Outputs approximate probability histograms generated using the Bayesian mixing model SIAR (Parnell et al. 2010).

Figure 2. (A) Map of the Nepeña Valley and the location of Caylán and Huambacho in relation to other Early Horizon sites. (B) Map of Peru showing coastal river valleys and archaeological sites mentioned in the text.

Figure 3. Chronology for the Initial Period and Early Horizon in the Nepeña Valley (Shibata 2010) presented alongside the widely utilized chronological divisions in Peruvian prehistory (EIP=Early Intermediate Period, LIP=Late Intermediate Period). Approximate temporal positions of major archaeological cultures or material culture traditions mentioned in the text are also presented.

Figure 4. Site map of Caylán showing excavation units and architectural contexts excavated in 2009 and 2010. The architectural context of each sample is given in Table 1.

Figure 5. Individual carbon and nitrogen isotopic compositions for Nepeña (circles for Caylán and triangles for Huambacho) camelids plotted relative to heat maps generated on the basis of previously measured camelids from modern highland pastures and archaeological sites (A) and camelids from coastal archaeological sites (B). To generate the heat maps, data from previous studies were binned according to 1‰ x 1‰ units.

Figure 6. SIAR density histograms showing estimated contributions of C₃ and C₄ plants for Nepeña (Caylán and Huambacho) camelids (middle panels) relative to highland camelids from a Middle Horizon site in the Callejón de Huaylas region (Chinchawas, top panel) and coastal camelids from an Early Intermediate Period site in the Virú Valley (Huaca Gallinazo, lower panel). In the second panel, three camelids with δ¹³C values > −16 ‰ are excluded.
Table 1. Isotopic and elemental compositions for Early Horizon camelids from Caylán and Huambacho. Specimens that have produced collagen deemed unreliable have been struck through.

<table>
<thead>
<tr>
<th>Context</th>
<th>Unit</th>
<th>Room</th>
<th>Stratum</th>
<th>Element</th>
<th>Sample #</th>
<th>δ¹³C (‰, VDPB)</th>
<th>δ¹⁵N (‰, AIR)</th>
<th>%C</th>
<th>%N</th>
<th>C:N</th>
<th>% Collagen</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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Supplementary Material – Analytical Precision and Accuracy

Carbon and nitrogen isotopic and elemental compositions were determined using an Isoprime continuous flow mass spectrometer coupled to a Costech Elemental Analyzer at the Archaeology Isotope Laboratory (The University of British Columbia). The following standard reference materials were used for calibration of δ^{13}C relative to VPDB and δ^{15}N relative to AIR (Table S1).

Table S.1. Standard reference materials used for calibration of δ^{13}C relative to VPDB and δ^{15}N relative to AIR for the Delta V.

<table>
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<tr>
<th>Standard</th>
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<th>Accepted δ^{13}C (‰, VPDB)</th>
<th>Accepted δ^{15}N (‰, AIR)</th>
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<td>USGS41</td>
<td>Glutamic Acid</td>
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The following internal standards were used to monitor accuracy and precision (Table S2).

The isotopic compositions reported here represent long term averages: methionine \((n=349)\), NIST 1577c \((n=195)\), SUBC-1 \((n=270)\), SRM-1 \((n=132)\), and SRM-2 \((n=119)\).

Table S.2. Standard reference materials used for to monitor internal accuracy and precision.

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<th>Standard</th>
<th>Material</th>
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<th>Accepted δ^{15}N (‰, AIR)</th>
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<tr>
<td>NIST 1577c</td>
<td>Bovine liver</td>
<td>−17.51±0.10</td>
<td>+8.15±0.15</td>
</tr>
<tr>
<td>SUBC-1</td>
<td>Seal bone collagen</td>
<td>−13.67±0.11</td>
<td>+17.39±0.14</td>
</tr>
<tr>
<td>SRM-1</td>
<td>Caribou bone collagen</td>
<td>−19.31±0.11</td>
<td>+1.81±0.11</td>
</tr>
<tr>
<td>SRM-2</td>
<td>Walrus bone collagen</td>
<td>−14.70±0.12</td>
<td>+15.58±0.10</td>
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</tbody>
</table>

Table S3 summarizes the mean and standard deviation of carbon and nitrogen isotopic compositions for all check standards, as well as the standard deviation for all calibration
standards – the mean of the calibration standard for an individual run is predetermined to calibrate the data.

**Table S3.** Accuracy and precision of calibration and check standards for all analytical sessions.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Type</th>
<th>Run ID</th>
<th>n</th>
<th>$\delta^{13}$C (‰, VPDB)</th>
<th>$\delta^{15}$N (‰, AIR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET</td>
<td>Check</td>
<td>G15-11</td>
<td>8</td>
<td>$-28.55\pm0.08$</td>
<td>$-5.01\pm0.19$</td>
</tr>
<tr>
<td>NIST 1577c</td>
<td>Check</td>
<td>G15-11</td>
<td>4</td>
<td>$-17.44\pm0.04$</td>
<td>$+8.32\pm0.16$</td>
</tr>
<tr>
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<td>Check</td>
<td>G15-11</td>
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<td>$+17.36\pm0.08$</td>
</tr>
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<td>Calibration</td>
<td>G15-11</td>
<td>7</td>
<td>$\pm0.14$</td>
<td>$\pm0.09$</td>
</tr>
<tr>
<td>USGS41</td>
<td>Calibration</td>
<td>G15-11</td>
<td>7</td>
<td>$\pm0.18$</td>
<td>$\pm0.17$</td>
</tr>
<tr>
<td>MET</td>
<td>Check</td>
<td>G15-12</td>
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<td>$-5.10\pm0.18$</td>
</tr>
<tr>
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<td>Check</td>
<td>G15-12</td>
<td>6</td>
<td>$-17.51\pm0.04$</td>
<td>$+8.15\pm0.12$</td>
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<td>$\pm0.14$</td>
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<td>G15-13</td>
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<tr>
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<td>$-4.94\pm0.08$</td>
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<tr>
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<td>$8.18\pm0.12$</td>
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<td>Check</td>
<td>G15-15</td>
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<td>$-5.03\pm0.10$</td>
</tr>
<tr>
<td>NIST 1577c</td>
<td>Check</td>
<td>G15-15</td>
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<tr>
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<td>Calibration</td>
<td>G15-15</td>
<td>9</td>
<td>$\pm0.08$</td>
<td>$\pm0.16$</td>
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<tr>
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<td>Calibration</td>
<td>G15-15</td>
<td>9</td>
<td>$\pm0.23$</td>
<td>$\pm0.19$</td>
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<tr>
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<td>Check</td>
<td>G15-16</td>
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<td>$-5.01\pm0.14$</td>
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<tr>
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<td>Check</td>
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<td>$+8.11\pm0.18$</td>
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<td>SUBC-1</td>
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<td>Calibration</td>
<td>G15-16</td>
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<td>$\pm0.11$</td>
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<td>Calibration</td>
<td>G15-16</td>
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<td>$\pm0.14$</td>
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<td>Check</td>
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<td>Check</td>
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<td>SUBC-1</td>
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<td>$+17.35\pm0.06$</td>
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<td>USGS40</td>
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<td>SUBC-1</td>
<td>Check</td>
<td>G15-21</td>
<td>6</td>
<td>$-13.67\pm0.08$</td>
<td>$+17.41\pm0.10$</td>
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<td>G15-21</td>
<td>9</td>
<td>$\pm0.04$</td>
<td>$\pm0.06$</td>
</tr>
</tbody>
</table>
At least ten percent of all samples were analyzed in duplicate to monitor for accuracy and precision (3 duplicates). For these replicates, the mean difference between pairs was 0.07 ‰ for $\delta^{13}$C and 0.02 ‰ for $\delta^{15}$N. These results are presented in full in Table S4. The boldface number in parentheses beside the first $\delta^{13}$C or $\delta^{15}$N value for each duplicate pair represents the difference between the two measurements for that sample.
Table S4. Carbon and nitrogen isotopic compositions for all duplicate sample pairs analyzed. Numbers in parentheses indicate differences between duplicates.

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>$\delta^{13}$C (‰, VPDB)</th>
<th>$\delta^{15}$N (‰, AIR)</th>
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</thead>
<tbody>
<tr>
<td>AIS 1305</td>
<td>−11.68 (0.04)</td>
<td>+10.77 (0.03)</td>
</tr>
<tr>
<td>AIS 1305 DUP</td>
<td>−11.64</td>
<td>+10.80</td>
</tr>
<tr>
<td>AIS 1315</td>
<td>−18.87 (0.15)</td>
<td>+6.17 (0.03)</td>
</tr>
<tr>
<td>AIS 1315 DUP</td>
<td>−19.02</td>
<td>+6.20</td>
</tr>
<tr>
<td>AIS 2592</td>
<td>−19.32 (0.02)</td>
<td>+4.30 (&lt;0.01)</td>
</tr>
<tr>
<td>AIS 2592 DUP</td>
<td>−19.30</td>
<td>+4.30</td>
</tr>
</tbody>
</table>