GROUND SLOTH EXTINCTION AND HUMAN OCCUPATION AT GRUTA DEL INDIO, ARGENTINA

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ABSTRACT. A new set of radiocarbon dates from a rockshelter in Mendoza, Argentina addresses the question of the temporal overlap between the presence of an unidentified extinct ground sloth (cf., Mylodontidae) and evidence of human activity. Dung balls on the cave floor, evidently deposited by sloth, are overlain by charcoal, apparently of cultural origin. ^{14}C dates, mostly on charcoal and dung from this shelter, calibrated using recently published curves, as well as the stratigraphy of the deposits from which the samples were collected, suggest that any co-occurrence of humans and ground sloths in this region was brief. In contrast, the single date on mylodon dermal ossicles from this shelter suggests significant time overlap. Replication of this date as well as obtaining new high-precision ^{14}C analyses from this site will be the next priority.

INTRODUCTION

Gruta del Indio is a rockshelter eroded out of a basaltic sequence located at Rincón del Atuel in southern Mendoza province, Argentina (34°45′S, 68°22′W), 660 m elevation, 28 km south of the town of San Rafael. In the stratigraphically lower portions, organic dung balls (boluses or *boñigas*) 4 × 6 cm, provided evidence for occupation by large animals, evidently South American ground sloth (*cf.* Mylodontidae), and the upper strata reveal evidence of human occupation (Lagiglia 1968). Vogel and Lerman (1969) reported the first radiocarbon dates on ground sloth dung, dermal ossicles and charcoal from hearths, which we attribute to human activity at Gruta del Indio, and established the site's antiquity. These dates suggested the possible coexistence of humans and extinct ground sloths near the end of the Pleistocene and the beginning of the Holocene. However, this overlap was not statistically significant, and if it occurred, it must have been brief. D'Antoni (1983) studied the paleoenvironment of both the surrounding area and within the rockshelter. His pollen analyses revealed the beginning of the Holocene to be the onset of higher temperatures and extreme aridity at Gruta del Indio. This climate change corresponded with the change in stratigraphy above the dung-containing zone.

A significant overlap in time between ground sloths and humans would imply their coexistence, whereas no lengthy stratigraphic or temporal overlap would be consistent with Martin's (1984, 1990) "blitz" model, in which humans, possibly as predators, were a catastrophic factor in the extinction of large mammals. The present study was initiated to re-examine the stratigraphic evidence for coexistence, and to establish a more extensive base of ^{14}C dates on both the charcoal and the sloth dung from Gruta del Indio.

Gruta del Indio

Figure 1 is a sketch of the Gruta del Indio shelter. It is one of the few known sites in South America that contain evidence of both extinct megafaunal and human presence. The gruta contains four distinguishable archaeological stages (Lagiglia 1968). The oldest, Atuel IV, contains dung of large mammals, charcoal fragments and apparent firepits. Atuel III, the next younger, contains early formative stage artifacts. The next higher level, Atuel II, contains evidence of agriculture. The most recent stage, Atuel I, is represented by pictographs, one showing Spanish soldiers and two possible boat landings

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(Semper and Lagiglia 1968). The work reported here focuses on the interface between Atuel IV and Atuel III, and specifically, the question of occupational and possible temporal overlap between large mammals and humans.

The presumed identity of the large mammals is based on the size of the dung balls and the morphology of the dermal ossicles recovered from the shelter. Dermal ossicles (pea-sized spherules of bone) are known only in the family Mylodontidae. Teeth associated with the dung represent both mylodontid and megatheriid ground sloths. Artifacts and ^{14}C dates suggest that occupation of the site may have been episodic over a significant range of time (Lagiglia 1968). This study focuses on the stratigraphic interface between the evidence for the earliest human occupation, essentially hearths and charcoal, and that for the latest large faunal visitation, the large dung balls. Seventeen previously unreported ^{14}C dates, in conjunction with newly available calibration curves, have enabled us to place limits on the time overlap of humans and extinct large animals at this locality. Figure 2 shows a vertical face of a trench through the shelter sediments where most of the samples for dating were taken for the present study. We found charcoal overlying dung layers; one firepit intruded into dung. No stratigraphic evidence revealed charcoal mixed with or overlain by dung. (See the Appendix for field collection notes.)

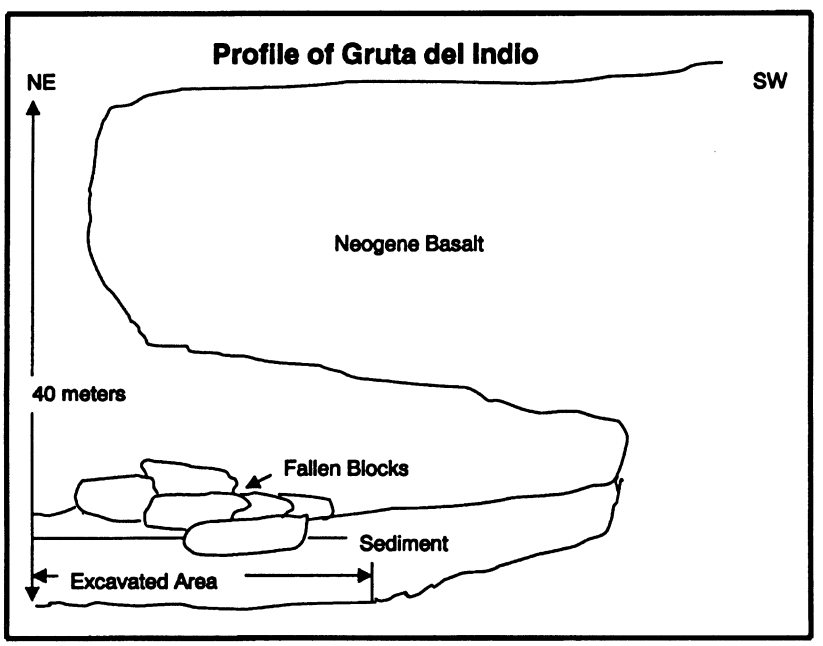

Fig. 1. Schematic section of Gruta del Indio

Radiocarbon Samples and Dates

Samples of both sloth dung and charcoal were taken in an attempt to obtain the stratigraphically youngest dung and oldest charcoal. Figure 3 is a photograph of one of the well-preserved dung balls. These are smaller than shasta ground sloth boluses from Rampart Cave, Arizona (Long *et al.* 1973) and much smaller than boluses from Mylodon Cave, Chile. In one case (A-9510) a hearth protruded into the dung layer. Table 1 summarizes the new ^{14}C dates obtained in this study, as well as all previous ^{14}C dates from this shelter, that the authors are aware of, and that are near and older than the Pleistocene/Holocene boundary. See Appendix 1 for sample collection notes. Dates with A-numbers

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between 1000 and 2000 are proportional-counter dates performed in the 1970s; those with A-numbers in the 9000s are liquid scintillation analyses performed recently in an underground counting chamber. GrN- dates were performed at the Groningen laboratory in the Netherlands in the 1950s and 1960s (Vogel and Lerman 1969) using gas-proportional counters. The last two columns in Table 1 give two calibrated cal yr 2-σ ranges representing each ^{14}C date. The next-to-the-last column

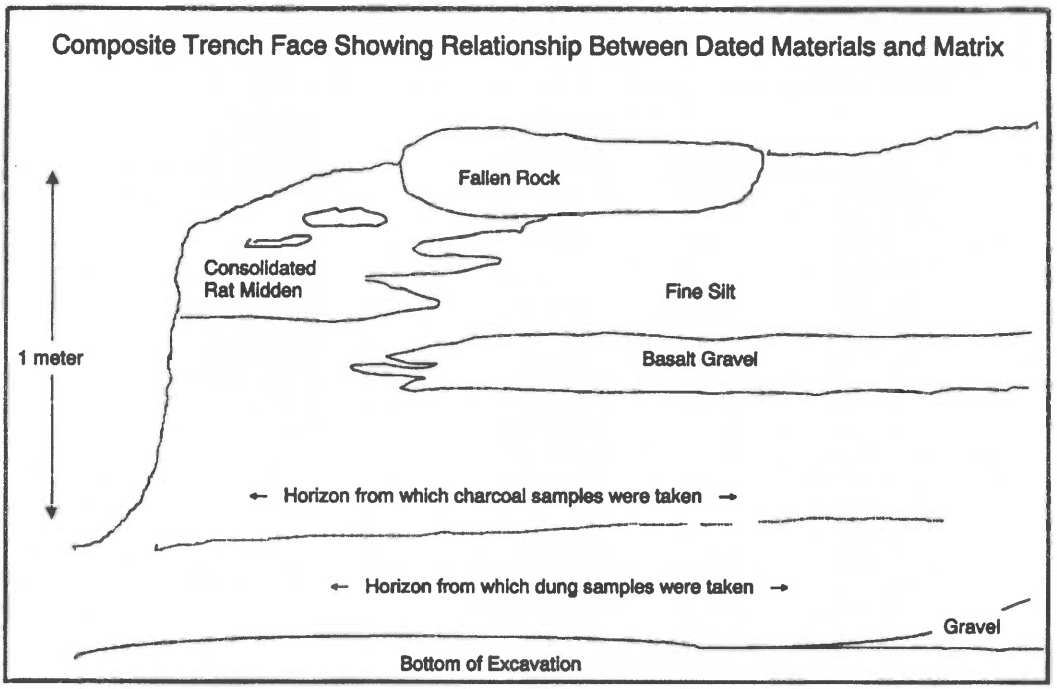

Fig. 2. Composite trench face where most samples were collected

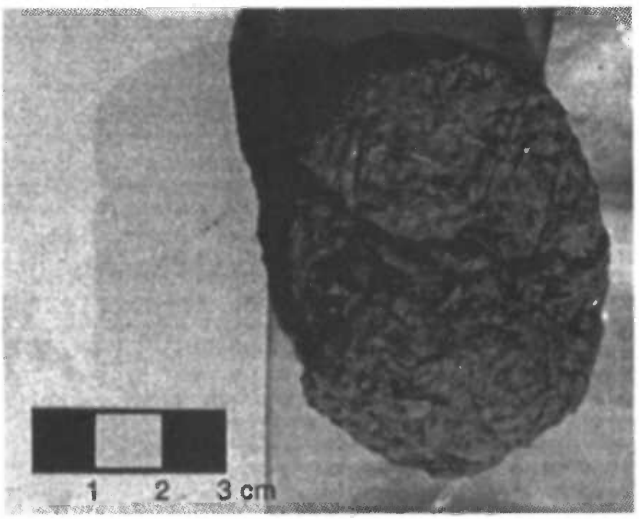

Fig. 3. Photograph of dung ball AL-75-1

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shows the range based on Burr *et al.* (1998), which includes the ^{14}C calibration data of Bard *et al.* (1993), and Kromer and Becker (1993), as well the coral-based ^{14}C data of Burr *et al.* (1998). The calibration range in last column in Table 1 includes the calibration data of Becker and Kromer (1993), and new marine varve ^{14}C data of Hughen *et al.* (1998). These calibration curves are conservative at the 2-σ level. The calibration procedure was manual. Table 1 shows calibrated age ranges only for the dates with 1-σ counting errors <200 yr.

TABLE 1. Radiocarbon Dates on Charcoal, Dung and Mylodon Dermal Ossicles from Gruta del Indio, Argentina

Sample type	Field no.	Lab no.	Conventional ^{14}C date (±1σ)	$\delta^{13}C$ (‰)	Calibrated age 2σ range (BP)*†	Calibrated age 2σ range (BP)*‡
Charcoal	AL-75-2	A-9486	10,135 ± 95	−23.2	11,020–12,380	10,900–12,400
Charcoal	AL-75-4	A-1637	9740 ± 280	−22.8		
Charcoal	AL-75-5	A-9487	10,440 +225/−220	−22.4		
Charcoal	AL-75-7	A-9489	9905 ± 140	−23.0	10,580–12,220	10,800–12,360
Charcoal	AL-75-9	A-9491	9770 ± 85	−22.3	10,570–11,670	10,650–11,600
Charcoal	AL-75-10	A-9492	9825 +95/−90	−23.6	10,640–11,920	10,800–12,350
Charcoal	AL-75-13	A-9495	9890 ± 75	−23.4	10,920–12,100	10,800–12,350
Charcoal	AL-75-14	A-9496	9990 ± 75	−23.0	11,000–12,150	10,960–12,350
Charcoal	AL-75-15	A-9497	10,195 ± 80	−23.0	11,120–12,440	11,050–12,400
Charcoal	AL-75-16	A-9498	10,170 ± 70	−23.4	11,100–12,400	11,050–12,400
Charcoal	AL-75-17	A-1638	10,530 ± 140	−23.1	11,680–12,880	11,450–12,980
Charcoal	F-3, 2.20 m	A-1373	10,930 ± 540	--		
Charcoal	Coll. by HAL	GrN-5394	8045 ± 55	−17.1	8600–9300	9000–9260
Dung	AL-75-1	A-9571	12,375 ± 115	−24.3	14,200–14,600	13,750–14,680
Dung	AL-75-3	A-1636	10,200 ± 300	−21.8		
Dung	AL-75-8	A-9570	11,040 ± 130	−22.5	12,420–13,700	12,700–13,250
Dung	AL-75-11	A-9493	10,900 ± 185	−24.7	12,000–13,700	12,050–13,250
Dung	AL-75-12	A-9494	10,285 +240/−230	−24.0		
Dung	Coll. by PSM	A-1282	9650 ± 800	--		
Dung	Quad 7 (70–80 cm)	A-1351	10,610 ± 210	−23.4		
Dung	Quad R-8, 70cm	A-1370	24,730 ± 860	--		
Dung	Quad 7 (80–90 cm)	A-1371	11,820 ± 180	--	12,920–14,500	13,050–14,680
Dung	PSM 6, 0–10 cm	A-1390	13,750 ± 400	--		
Dung	RR-8, 1.10m Deepest level	GrN-5558	10,950 ± 60	−22.9	12,600–13,800	12,700–13,070
Wood	Assoc. with Dung, Q-RR, 1.0-1.1m	A-1372	−32,000	--		
Mylodon, Dermal Ossicles	Coll. by HAL	GrN-5772	9560 ± 90§	−11.5	10,200–11,000	10,300–11,600

*Samples with σ ≥200 yr are not included in these columns.
†Calibrated using Burr *et al.* (1998)
‡Calibrated using Hughen *et al.* (1998)
§If this date was not originally adjusted for isotopic fractionation, add 220 yr.

DISCUSSION

We undertook this study to apply stratigraphy and ^{14}C dating to define the time period of overlap, if any, between mammal and human use of this site. In the time since the fieldwork was done, detailed calibrations of the ^{14}C time scale have revealed a period of 500 to 800 yr that predates living dendrochronologically dated trees, during which a relatively high level of ^{14}C in the atmosphere led to

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a "plateau" (horizontal section) of the calibration curve. Unfortunately, this occurred at a time when some of the most interesting and important events in geology, anthropology and paleontology took place. One of these events may be recorded in the Gruta del Indio stratigraphy. Even the highest-precision ^{14}C dates cannot overcome the fact that samples yielding an apparent ^{14}C age of 10,000 BP can have "true" calendar dates anywhere between 11,200 and 11,700 yr.

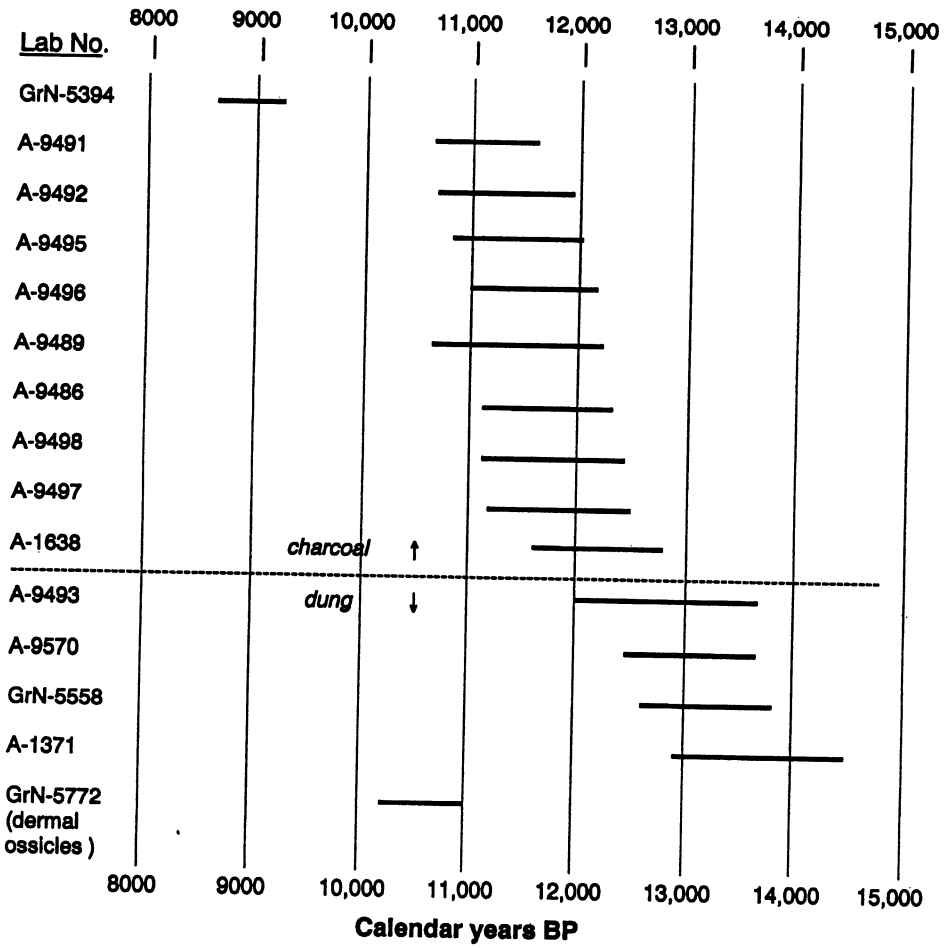

Fig. 4A. Dates with standard deviations 200 yr, calibrated using curve of Burr *et al.* (1998)

The only data selection employed here was to place greater emphasis on ^{14}C dates with lower standard deviations. This essentially amounts to assigning a weighting factor of 1 to those dates with $\sigma < 200$, and 0 to those dates with $\sigma > 200$. With this restriction, the dates with lower standard deviations show no overlap between the charcoal and the dung at the 1-σ confidence level. With the more precise dates, and the 2-σ uncertainty range, the calibration procedures employed here yielded the widest, most conservative range of statistically possible calibrated ages for the samples. The general consensus is that the tree-ring-based portion of the calibration curve is secure. More recent tree-ring ^{14}C data of Kromer *et al.* (1998) show that a further extension of the curve continues its mostly flat trajectory. The coral-based portion of the calibration curve is less certain because the ^{14}C content of corals depends on the ^{14}C of the ocean surface water in which they grew. This is controlled not only

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by the ^{14}C of the atmosphere, but also by the degree of mixing, if any, with deeper water, which may have had lower levels of ^{14}C at times in the past. Marine varves, as employed in the Hughen *et al.* (1998) calibration curve, also possibly have an unrecognized marine offset. Corrections for this effect are challenging, but it seems likely that the ranges of calibrated dates in Table 1, plotted in Figures 4A,B conservatively cover the 95% probability range. It is not possible at this time to know which of the two calibration curves is closer to reality, but for our current data set, it makes little difference. Our data show minor overlap of calibrated age ranges between sloth dung and charcoal ^{14}C dates. We interpret this to mean that coexistence of sloth and humans at Gruta del Indio was brief, if it occurred. It is also possible that if A-1638 and A-9493 were to have higher precision (smaller ± figures), the charcoal and dung might not overlap at the 2-σ level. Unfortunately, sample-size limitations precluded high precision at the time of measurement. Selected samples will be redated by accelerator mass spectrometry (AMS) in an attempt to resolve the question of time overlap.

One ^{14}C date on cf. mylodon ossicles is anomalous. This sample was from a museum collection, not collected or analyzed in this study. Thus, although normal acid-base-acid pretreatment was

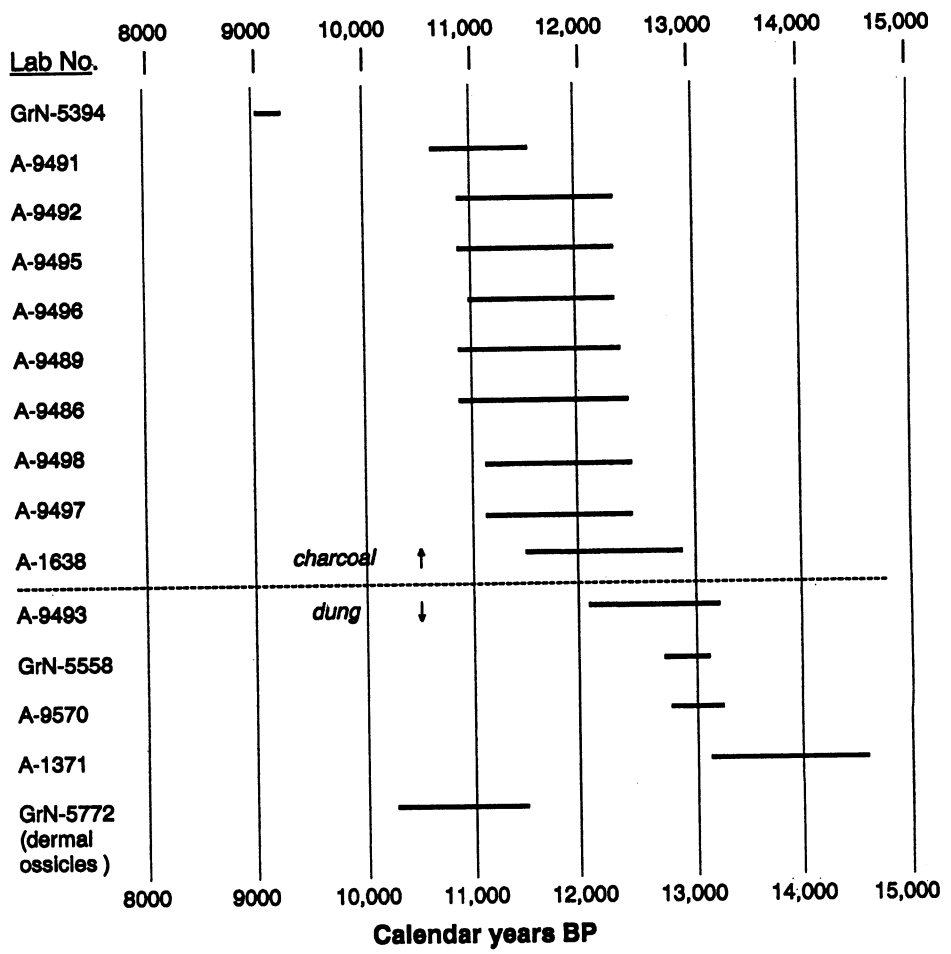

Fig. 4B. Dates with standard deviations 200 yr, calibrated using curve of Hughen *et al.* (1998)

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employed (J. van der Plicht, personal communication 1998), we cannot be certain that preservatives, if applied, were completely removed.

Summary and Conclusion

Stratigraphic studies and new ^{14}C dates at Gruta del Indio, a rockshelter in west-central Argentina, reveal possible, but not secure evidence for time overlap of extinct faunal remains, probably mylodontid, with human occupation. Stratigraphic overlap was not evident in the exposed trenches. Only for specimens with relatively large ± figures do calibrated ^{14}C date ranges of dung overlap those of charcoal. A repeat of these dates at higher precision, or new collections and dates, are needed to confirm a time gap between charcoal and dung. New AMS dates should also be carried out on amino acid fractions preserved in dermal ossicles.

If human occupation occurred a few years, or even a few decades after ground sloths occupied the Gruta, and if the ^{14}C-dated samples represent the last of the extinct animals and the first evidence of humans, as we attempted to detect in our sampling, more than one pair of the dating uncertainty ranges of charcoal should have clearly overlapped with those of the dung. Except for the dermal ossicles, overlap is ambiguous.

Acknowledgments

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APPENDIX. Field Collection Notes, Gruta del Indio Archaeological Site, Argentina

Lab no.	Field no.	Description and comments
A-1282		Dung, Quad 7, level 7, coll. by HAL
A-1351		Dung, Quad 7, level 7, 70–80 cm, coll. by HAL
A-1370	PSM #1(A)	Dung, Quad R.8, 70–80 cm, coll. by PSM and HAL
A-1371	PSM #2(A)	Dung, Quad 7, level 8, 80–90 cm, coll. by HAL
A-1372	PSM #3(A)	Wood associated with dung, Quad RR-9, 1.0–1.1m, coll. by HAL
A-1373	PSM #4	Charcoal, Quad F-3, 2.20 m, coll. by HAL
A-1390	PSM #6	Dung, Quad 7, 0–10 cm, coll. by PSM, HAL
A-1636	AL-75-3	Degraded dung ball, O-5 red layer, stratigraphically highest dung in south face of the trench, coll. by AL
A-1637	AL-75-4	Charcoal from red layer, O-5, stratigraphically lowest charcoal in south face of the trench, coll. by AL
A-1638	AL-75-17	Charcoal from F-2 firepit at 2.68 m below original surface, coll. by AL
A-9486	AL-75-2	Charcoal from west face of P-6, near firepit 2, coll. by AL
A-9487	AL-75-5	Charcoal from fire hearth no. 1 in red layer in O-5, south face. Apparently stratigraphically higher than AL-75-4, though physically lower, coll. by AL
A-9489	AL-75-7	Charcoal from E face of O-5, just above dung layer, coll. by AL
A-9491	AL-75-9	Charcoal from E face of O-5 in gray layer, 1.5–2.0 cm above dung layer, coll. by AL
A-9492	AL-75-10	Charcoal from firepit no. 3, evidently dug into sloth-dung layer, coll. by AL
A-9493	AL-75-11	Dung from top of dung layer near firepit 3, coll. by AL
A-9494	AL-75-12	Single dung ball at top of dung layer, coll. by AL
A-9495	AL-75-13	Charcoal from top of hearth layer, coll. by AL
A-9496	AL-75-14	Charcoal from charcoal-rich zone between top and middle hearth layers, coll. by AL
A-9497	AL-75-15	Charcoal from middle hearth zone, coll. by AL
A-9498	AL-75-16	Charcoal from lowest hearth zone, coll. by AL
A-9570	AL-75-8	Distinct but degraded dung balls from top of dung layer
A-9570	AL-75-1	Dung from P-6, 60 cm below datum surface, coll. by AL, PSM, HAL
GrN-5394		Wood charcoal from hearth above dung horizon, associated with dermal ossicles of *Mylodon listai,* Grid RR-9.
GrN-5558		Dung from deepest level of rockshelter 1.10m below surface, RR-8
GrN-5772		Mylodon dermal ossicles, coll. by HAL

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