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EL MIRÓN CAVE AND THE ^{14}C CHRONOLOGY OF CANTABRIAN SPAIN

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ABSTRACT. Excavations since 1996 in the large El Mirón Cave in the Cantabrian Cordillera of northern Spain have revealed a cultural sequence of late Mousterian, early Upper Paleolithic, Solutrean, Magdalenian, Azilian, Mesolithic, Neolithic, Chalcolithic, Bronze Age, and Medieval occupations. These components have been dated by 51 generally coherent radiocarbon determinations, all run by the Geochron labs, in association with the Lawrence Livermore labs for AMS. This series is one of the largest for a single prehistoric site in Iberia or even Europe. The series is consistent with the record from Cantabrian Spain and provides new detail on the age of the Middle–Upper Paleolithic transition, on the various phases of the Magdalenian culture, on the appearance of the Neolithic in the Atlantic zone of Spain, and on the origins of the socioeconomic complexity in the metal ages. The stratigraphic relationship of ^{14}C-dated levels to a roof-fall block and adjacent cave walls (both with engravings) provides rare *terminus post* and *ante quem* ages for execution of the rupestral art in El Mirón during the early to mid Magdalenian. The ^{14}C record has also been instrumental in revealing the existence of depositional hiati during the early Holocene.

INTRODUCTION

To avoid the pitfalls of using multiple laboratories, current prehistoric research in the Río Asón Valley in Cantabria, Spain (including not only the El Mirón Cave excavation co-directed by the present authors with 51 radiocarbon determinations, but also those of La Fragua, El Valle, and El Horno caves, directed by González Morales, M P García-Gelabert, and M Fano, respectively) has exclusively used the services of Geochron for ^{14}C dating (González Morales and Straus 2000; Straus et al. 2001, 2002 a,b). The present article is, therefore, a posthumous homage to Hal Krueger, a pioneer in archeological isotopic analyses and in high-quality professional service to the disciplines of archeology and geology. It was Hal who ran the dates from the first season at El Mirón in 1996 with results as promising as they were spectacular. Alex Cherkinsky, who ran most of the dates after Hal, has continued Krueger's tradition of rigor and rapidity at Geochron, which are part of Hal's legacies.

^{14}C DATING THE STONE AGE PREHISTORY OF CANTABRIAN SPAIN

The first attempts at ^{14}C dating Paleolithic materials (namely, charcoal from the Magdalenian sites of Altamira and El Juyo and, less successfully, mollusc shells from Altamira) in the Cantabrian Region of Spain were made by H R Crane and J B Griffin (1960) of the University of Michigan over 40 yr ago. The results of the charcoal dates have been generally confirmed with determinations from new excavations in both sites (Freeman 1988, 1996). The first excavation project in this classic prehistoric culture area to incorporate ^{14}C dating as an integral part of its modern, interdisciplinary methodology was that of Cueva Morín, directed by J González Echegaray and L G Freeman in the late 1960s. The dating was done entirely by R Stuckenrath (1978) at the now-defunct Smithsonian Institution Radiation Biology Laboratory. Despite some stratigraphic inversions and a high degree of imprecision among some of the determinations, the 9 dates from Morín are still cited as among the relatively few that we have for the initial phases of the Upper Paleolithic in Cantabria. Following on the Morín Project one of its student participants, G A Clark (1976), undertook to definitively resolve the question of the age of the "Asturian culture", in large part by the first-ever application of ^{14}C dating to samples from the shell middens of eastern Asturias.

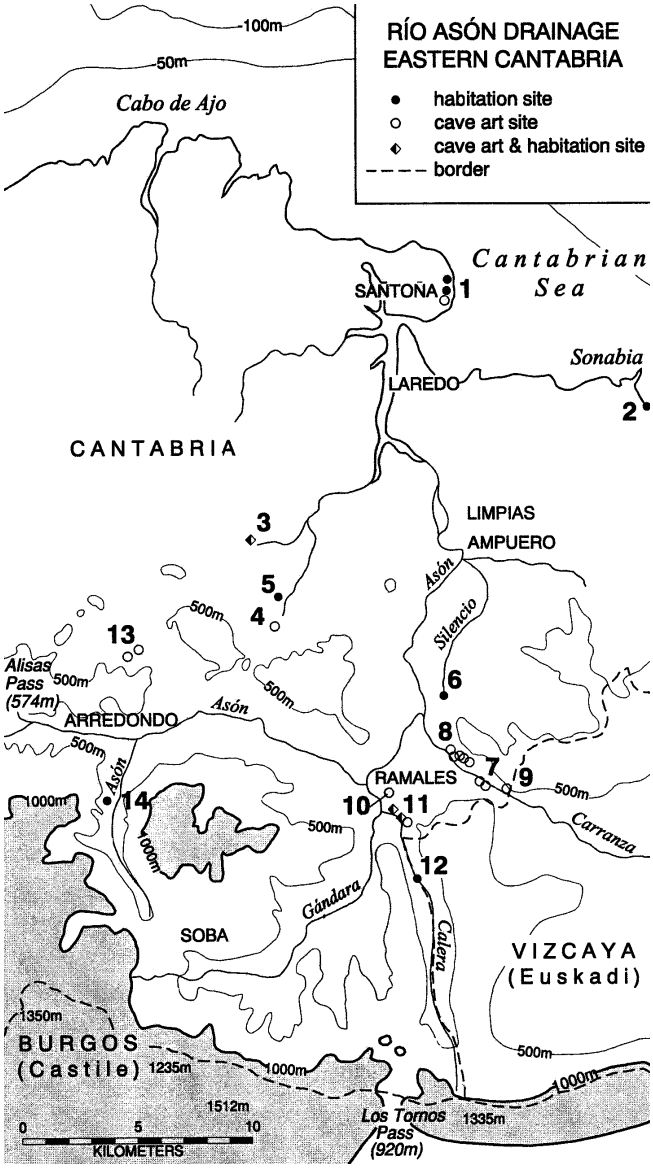

Figure 1 Map of the Asón River valley in eastern Cantabria: El Mirón & El Horno caves are two of the sites at 11; El Perro & La Fragua at 1; El Valle at 6; Cubio Redondo at 13; Tarrerón at 12

When organizing the La Riera Paleoecological Project in 1975, Clark and Straus proposed to make extensive use of ^{14}C dating to provide the chronological framework of the sequence at La Riera Cave in eastern Asturias, rather than essentially relying on "diagnostic" artifact presence or percentages to attribute specific strata to particular cultural-historical phases. The result of systematic ^{14}C assays for the 2.5 m of deposit (30 levels) was a list of 28 dates ranging in age from about 21,000 to 6500 BP (Straus and Clark 1986). Unfortunately, in part to take advantage of some offers of free dates, we obtained determinations from 5 different laboratories. Due to this fact and the subsequent interlaboratory errors (International Study Group 1982), combined with undoubted interlevel disturbances and sample movements in a stratigraphy composed of very thin levels with no culturally sterile zones, it is clear that there are many reasons probably responsible for some of the incoherences

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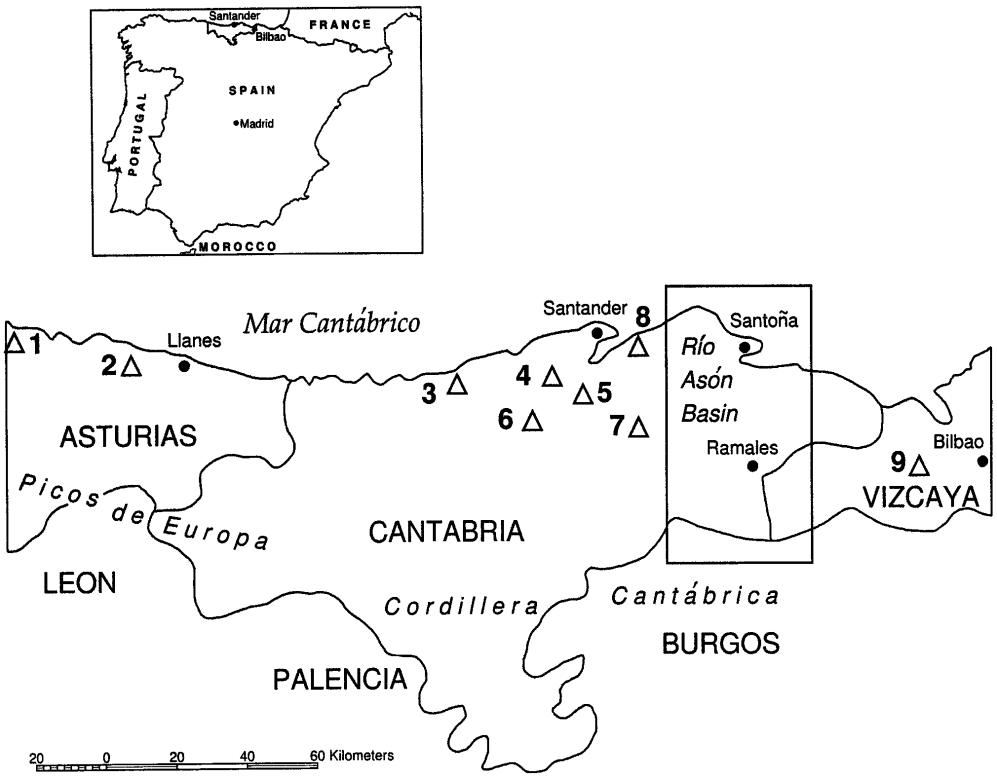

Figure 2 Map of the central part of Cantabrian Spain, showing locations of the Asón River drainage and of some major Paleolithic sites, 2=La Riera; 3= Altamira; 4=El Juyo; 5=Morín; 6=Castillo; 7=Rascaño

among the La Riera dates, as have often been commented upon and criticized. Nonetheless, the La Riera sequence, in association with other sites that were being ^{14}C-dated in the 1970s and 80s, clearly established the following sequence for the late Upper Paleolithic and Mesolithic in the Cantabrian region:

- Solutrean: 20,500–17,000 BP;
- early (= Lower + Middle) Magdalenian: 17,000–13,000 BP;
- Upper Magdalenian: 13,000–11,500 BP;
- Azilian: 11,500–9000 BP;
- Asturian/Mesolithic: 9000–6000 BP (all dates uncalibrated).

Subsequently, several other excavation projects in northern Atlantic Spain have invested fairly heavily in ^{14}C dating despite initial, and some on-going, skepticism about the reliability of the method on the part of some traditional prehistorians. Notable in this context have been the Middle Río Nalón Project organized by J Fortea (and in which González Morales and M S Corchón have been major participants), numerous excavations in the Basque province of Guipúzcoa directed by J Altuna et al. of the Aranzadi Scientific Society (e.g., Ekain, Erralla, Amalda, Aitzbitarte, Labeko), the Río Asón Estuary Project directed by González Morales (1995), the re-excavation of El Castillo Cave directed by V Cabrera (Cabrera and Bernaldo de Quirós 2000; Cabrera et al. 1996), the La Garma Complex and Cantabrian Neolithic Projects directed by P Arias (Arias et al. 1999, 2000), and most spectacularly, the various projects to directly date Cantabrian cave art by AMS, the latest

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results of which have recently been reported by Moure and González Sainz (2000 a,b) and Fortea (2002). There is no up-to-date, global compilation of ^{14}C dates for the Upper Paleolithic and Mesolithic of northern Spain. However, there is a complete list of all ^{14}C dates (including even the Iron Age, Roman period, and Middle Ages) from the Spanish (and French) Basque country as of a decade ago (Mariezkurrena 1990). Straus (1992) published all known ^{14}C dates for the Paleolithic and Mesolithic of the whole geographic macro-region (the autonomous administrative regions of Euskadi, Navarra, Cantabria, and Asturias). There have been no major compilations since then, except the Alvarez and Jöris' (1998) calibration of dates for the mid-Magdalenian at Las Caldas and other sites.

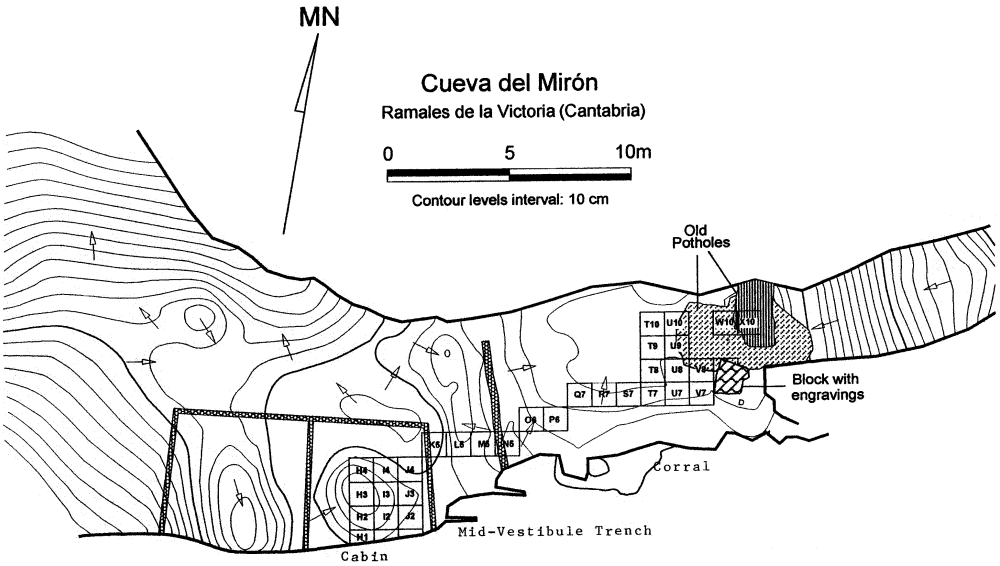

Figure 3 Plan of the El Mirón Cave vestibule, showing the location of our excavations

EL MIRÓN CAVE

El Mirón is a large cave in Monte Pando. It was scientifically discovered by L Sierra and H Alcalde del Río in 1903 (along with the adjacent cave art sites of Covalanas and La Haza), but was largely ignored or written off as totally disturbed ever since. This massif of highly-karstic, Lower Cretaceous limestone is one of the coastward ranges of the Cantabrian Cordillera in easternmost Cantabria Province, on the border with Vizcaya and near the border with the *meseta* of Burgos (Old Castile) at the low (920 m above sea level) Los Tornos Pass (Figure 1). The site is at the strategic confluence of 2 tributary gorges with the major Ruesga Valley (the intermontane course of the Río Asón) a river that drains a large region midway between the coastal cities of Santander and Bilbao (Figure 2). Excavation of El Mirón represents the first large-scale, modern-quality, archeological research project to be conducted in the mountainous interior of Cantabria. Until recently, most excavations had been done at sites on or near the narrow coastal plain along the Bay of Biscay. The large, flat-floored cave vestibule is mainly dry and faces due west. Located above the important market town of Ramales on the valley floor, El Mirón was occupied by humans and livestock until recently. It is surrounded by about a dozen known cave art localities, none excavated.

Our excavations in El Mirón (seven 2-month campaigns since 1996) have been concentrated in 2 areas of the large (10 × 30 m) vestibule: front ("Cabin") and rear ("Corral"), each at most about 10

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m^2 in size (Figure 3). We have connected these 2 block excavations with a continuous stratigraphic trench (8 m long × 1 m wide). We also regularized and deepened a never-published trench that had been dug in the dark inner cave during the 1950s. Access to the lower part of the stratigraphy was provided by emptying and screening the totally-mixed contents of a large pothole at the foot of a steep slope of (Tertiary?) colluvial-alluvial sediments leading up into the inner cave at the back of the vestibule. The clandestine digging had stopped at the base of the series of organically-rich Magdalenian layers, leaving intact all strata from Solutrean times downward.

In the vestibule front area, the cultural-historical sequence currently includes layers pertaining to the Bronze Age, Chalcolithic, Neolithic, Mesolithic, Azilian, and the Upper and Lower/Middle Magdalenian (Figure 4). The main excavation in the former corral lacks the ceramic components

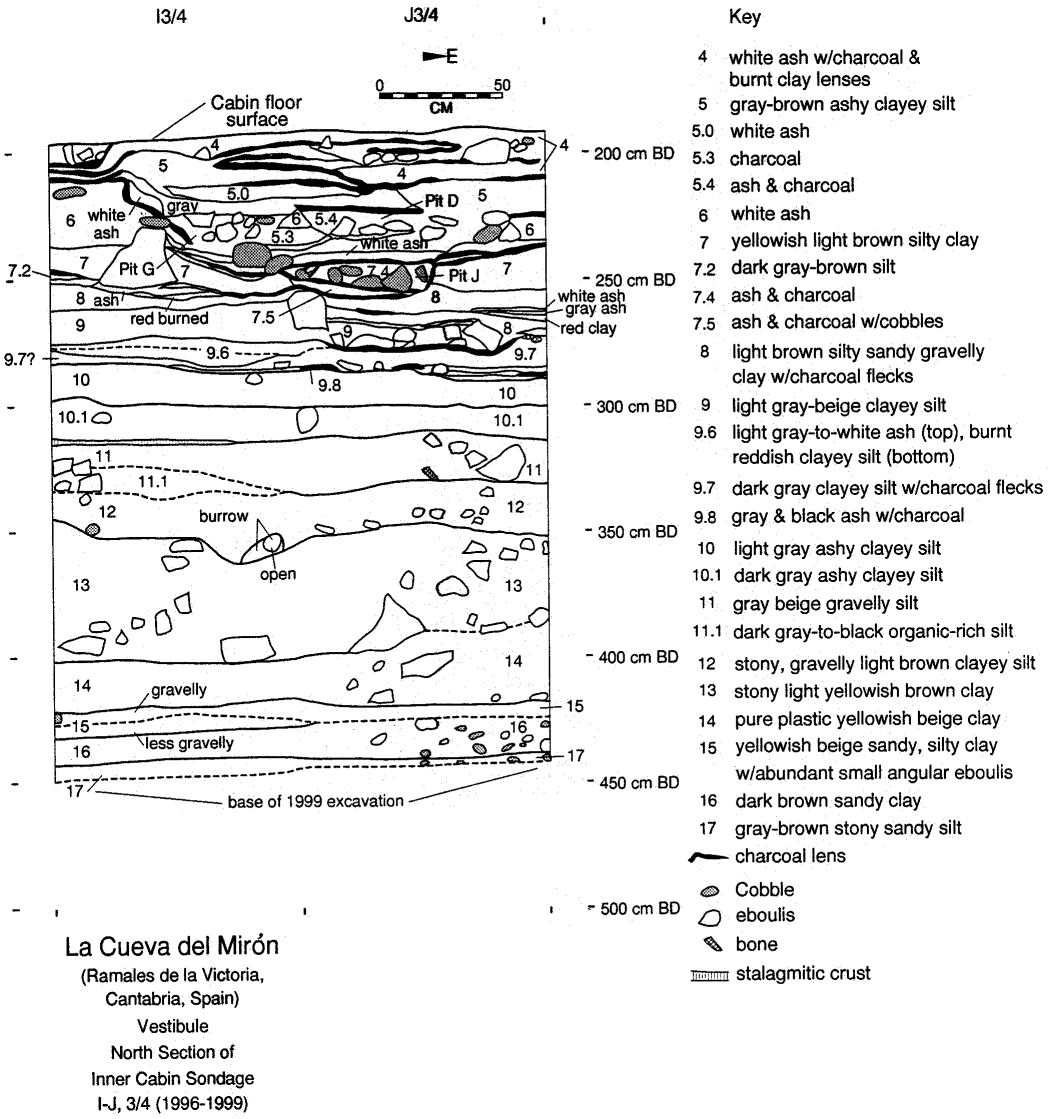

Figure 4 Stratigraphic section of the excavation near the front of the vestibule ("Cabin" area)

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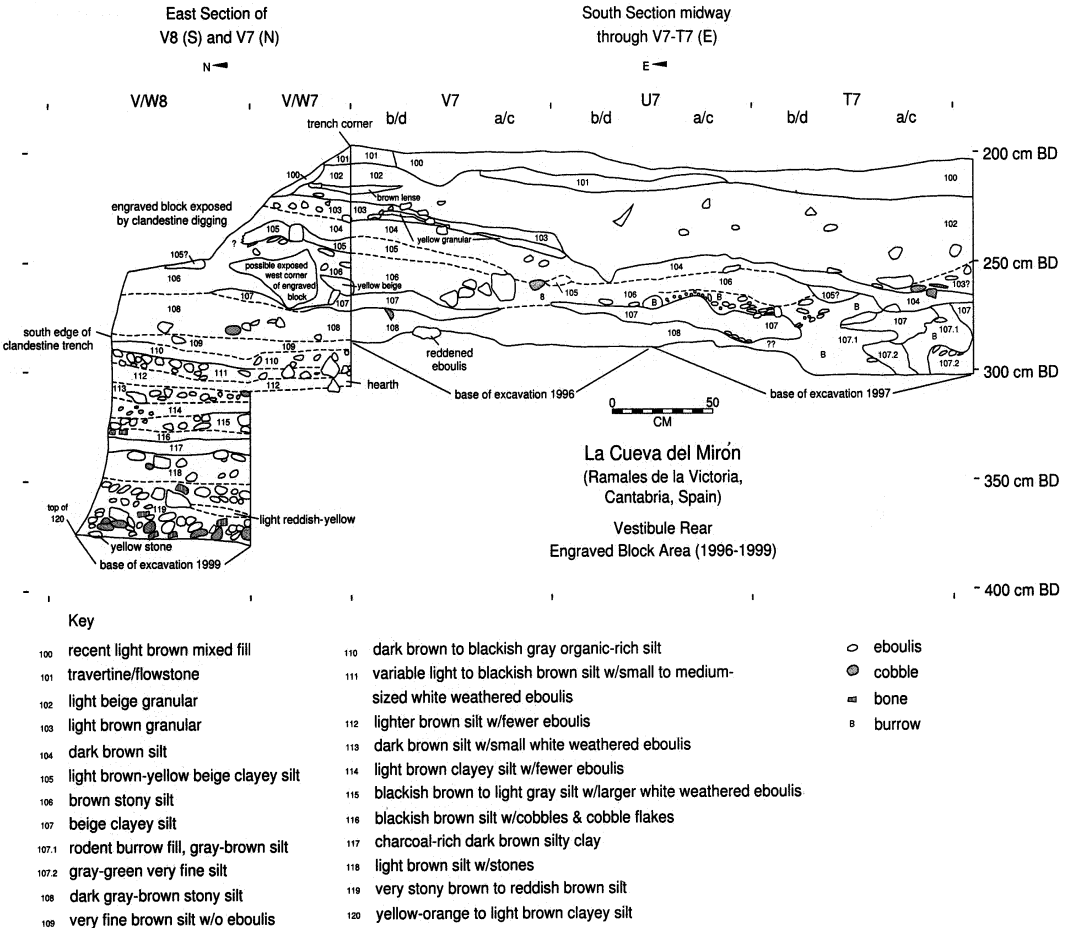

Figure 5 Stratigraphic section of the excavation at the rear of the vestibule ("Corral" area)

and has a sequence of possible Mesolithic, then Azilian, Upper, Middle, and Lower Magdalenian layers (Figure 5). The 2 × 1 m test pit in the base of the pothole has a sequence of Solutrean, Early Upper Paleolithic, and Mousterian strata (Figure 6). To date, the mid-vestibule connecting trench has revealed remnant Bronze Age/Chalcolithic and Neolithic deposits toward the cave mouth; these are underlain by a nearly sterile layer of Mesolithic age and then Azilian and Upper and Middle Magdalenian levels (Figure 7). The inner cave trench revealed a bonfire layer of Medieval age with only faunal remains, a series of sterile clay and mondmilch layers (but with possible torch fragments dating to the Bronze Age), and at the base, a Middle Magdalenian layer (Figure 8). Ground-penetrating radar, magnetometry, and electrical resistivity surveys of the vestibule have shown that there are approximately 9 m of sedimentary deposits above the bedrock. In aggregate total at the rear of the vestibule, we have excavated to a depth of about 5 m below the ground surface, and in the front, we have dug down no more than about 3.5 m as of the end of the summer 2002 campaign, although core boring in 2003 showed at least approximately 1 m more cultural deposits below the base of the excavation.

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Table 1 El Mirón Cave ^{14}C dates (1996–2002)

Square	Zone[a]	Level	Spit	Period[b]	Date (BP)	1 SD	Material[c]	Lab nr	Method[d]	Calibrated date[e]
H2	OV	3	4	BA	3700	40	Ch	GX-25851	AMS	2140–2030 BC
J2	OV	5	3	Chal	3820	240	Ch	GX-22127	Conv	2575–1931 BC
I3	OV	5.1	4	Chal	4120	50	Ch	GX-22130	AMS	2858–2586 BC
H2	OV	7	14	Chal	3740	120	Ch	GX-22460	Cxcnt	2305–1963 BC
I3	OV	8.1	13	Neo?	4680	60	Ch	GX-22131	AMS	3612–3371 BC
J2	OV	9	8	Neo	5170	170	Ch	GX-22128	Conv	4221–3789 BC
H4	OV	9	22	Neo	5280	40	Ch	GX-24461	AMS	4217–4001 BC
I4	OV	9.6	22	Neo	5250	150	Ch	GX-24462	Cxcnt	4318–3945 BC
I3	OV	10	19	Neo	5570	50	Ch	GX-23414	AMS	4449–4359 BC
I3	OV	10	19	Neo	5690	50	Ch	GX-23413	AMS	4582–4458 BC
J4	OV	10.1	34	Mes	8380	175	Ch	GX-24463	Cxcnt	7586–7182 BC
I4	OV	10.1	28	Mes	8700	40	Ch	GX-25852	AMS	7745–7609 BC
I4	OV	10.1	29	Mes	9550	50	Ch	GX-24464	AMS	9119–8792 BC
I3	OV	11.1	25	AZ/UM	11,720	140	Ch	GX-23391	Conv	12,039–11,523 BC
J2	OV	12	12	UM	12,970	70	Bc	GX-22132	AMS	13,990–13,299 BC
I3	OV	15	43	LM	15,010	260	Ch	GX-23392	Conv	16,396–15,609 BC
I3	OV	15	43	LM	15,220	300	Bc	GX-23393	AMS	16,679–15,810 BC
I3	OV	16	44	LM	15,180	100	Bc	GX-23415	Conv	16,487–15,910 BC
J3	OV	17	32	LM	15,470	240	Bc	GX-24466	Conv	16,919–16,145 BC
J3	OV	17	39	LM	15,450	160	Bc	GX-27115	Cxcnt	16,852–16,184 BC
J2	OV	17	20	LM	15,700	190	Ch	GX-25853	Conv	17,151–16,441 BC
O6	MV	302?	Pit98a	Neo?	4910	80	Ch	GX-28211	Conv	3773–3641 BC
L5	MV	303	13	Neo	5500	90	Ch	GX-25854	Conv	4451–4250 BC
L5	MV	303.1	14	Neo	5520	70	Ch	GX-25855	Conv	4451–4261 BC
L5	MV	303.3	16	Neo	5790	90	Ch	GX-25856	Cxcnt	4768–4540 BC

[a]IC=inner cave; OV=outer vestibule ("Cabin"); VR=vestibule rear ("Corral"); MV=mid-vestibule ("Trench")

[b]Med=Medieval; BA=Bronze Age; Chal=Chalcolithic; Neo=Neolithic; Mes=Mesolithic; AZ=Azilian; UM=Upper Magdalenian; MM=Middle Magdalenian; LM=Lower Magdalenian; Sol=Solutrean; EUP=Early Upper Paleolithic; MP=Middle Paleolithic (Distinctions between Azilian & Upper Magdalenian and between Middle & Lower Magdalenian are tentative)

[c]Ch=charcoal; Ta=tooth bioapatite; Tc=tooth collagen; Bc=bone collagen

[d]AMS=accelerator; Conv=conventional; Cxcnt=extended count

[e]Stuiver et al. (1998); CALIB 4.1.2 (Range at 1 sigma)

Table 1 El Mirón Cave ^{14}C dates (1996–2002) *(Continued)*

Square	Zone[a]	Level	Spit	Period[b]	Date (BP)	1 SD	Material[c]	Lab nr	Method[d]	Calibrated date[e]
P6	MV	305	9	AZ	10,270	50	Bc	GX-24467	AMS	10,362–9818 BC
P6	MV	306	11	AZ/UM	11,650	50	Bc	GX-24468	AMS	11,861–11,525 BC
P6	MV	308	16	UM	12,350	180	Ch	GX-28210	Cxcnt	13,403–12,166 BC
U7	VR	surface	#[f]	Med	540	100	Ch	GX-24465	Cxcnt	AD 1304–1442
T8	VR	102.1	3	AZ/UM	11,950	70	Bc	GX-23417	AMS	12,136–11,890 BC
V8	VR	108	4	MM	13,660	70	Bc	GX-22703	AMS	14,689–14,209 BC
V8	VR	108	5	MM	14,710	160	Bc	GX-23397	Conv	15,969–15,346 BC
T10	VR	108”	8	MM	14,850	60	Ch	GX-27114	AMS	16,092–15,559 BC
V8	VR	110	8	MM	16,130	250	Bc	GX-23396	Conv	17,699–16,884 BC
V8	VR	111	14	MM	16,370	190	Bc	GX-23395	Conv	17,935–17,201 BC
U7	VR	111	20	MM	15,530	230	Bc	GX-24469	Conv	16,981–16,221 BC
T10	VR	114	17	LM	16,460	50	Bc	GX-28209	AMS	17,989–17,364 BC
V8	VR	115	19	LM	13,800	840	Bc	GX-23394	Conv	15,725–13,517 BC
V8	VR	116	20	LM	15,220	100	Bc	GX-23416	AMS	16,534–15,955 BC
V7	VR	116[g]	26	LM	17,400	80	Ch	GX-29439	AMS	19,082–18,424 BC
V8	VR	117	24	LM	17,050	60	Ch	GX-25857	AMS	18,760–18,031 BC
V8	VR	119	28	LM/Sol	16,960	80	Ch	GX-25858	AMS	18,570–17,923 BC
W10	VR	125	4	Sol	18,980	360	Bc	GX-24470	Conv	21,106–20,035 BC
W10	VR	126	5	Sol	18,950	350	Bc	GX-24471	Conv	21,065–20,007 BC
X10	VR	128	20	EUP	27,580	210	Ch	GX-27113	AMS	—
X10	VR	130	36	MP	41,280	1120	Ch	GX-27112	AMS	—
Slope	top IC	Flowstone	AZ	—	10,740	40	Ta	GX-27521a	AMS	10,984–10,699 BC
Slope	top IC	Flowstone	AZ	—	10,390	50	Ch	GX-27521c	AMS	10,665–10,024 BC
8-9Q	IC	IV	—	Med	900	80	Ch	GX-22129	Conv	AD 1040–1204
11Q	IC	VII	—	BA	3230	40	Ch	GX-28013	AMS	1523–1441 BC
11R	IC	VIII	10	MM	14,620	80	Ch	GX-22347	AMS	15,818–15,290 BC

[a]IC=inner cave; OV=outer vestibule (“Cabin”); VR=vestibule rear (“Corral”); MV=mid-vestibule (“Trench”)

[b]Med=Medieval; BA=Bronze Age; Chal=Chalcolithic; Neo=Neolithic; Mes=Mesolithic; AZ=Azilian; UM=Upper Magdalenian; MM=Middle Magdalenian; LM=Lower Magdalenian; Sol=Solutrean; EUP=Early Upper Paleolithic; MP=Middle Paleolithic (Distinctions between Azilian & Upper Magdalenian and between Middle & Lower Magdalenian are tentative)

[c]Ch=charcoal; Ta=tooth bioapatite; Tc=tooth collagen; Bc=bone collagen

[d]AMS=accelerator; Conv=conventional; Cxcnt=extended count

[e]Stuiver et al. (1998); CALIB 4.1.2 (Range at 1 sigma)

[f]Large lump of charcoal apparently fallen into the excavation from Corral area surface after removal of the top ~20 cm of recent dirt and dung

[g]Sample charcoal is from hearth pit dug within or from the indicated stratum

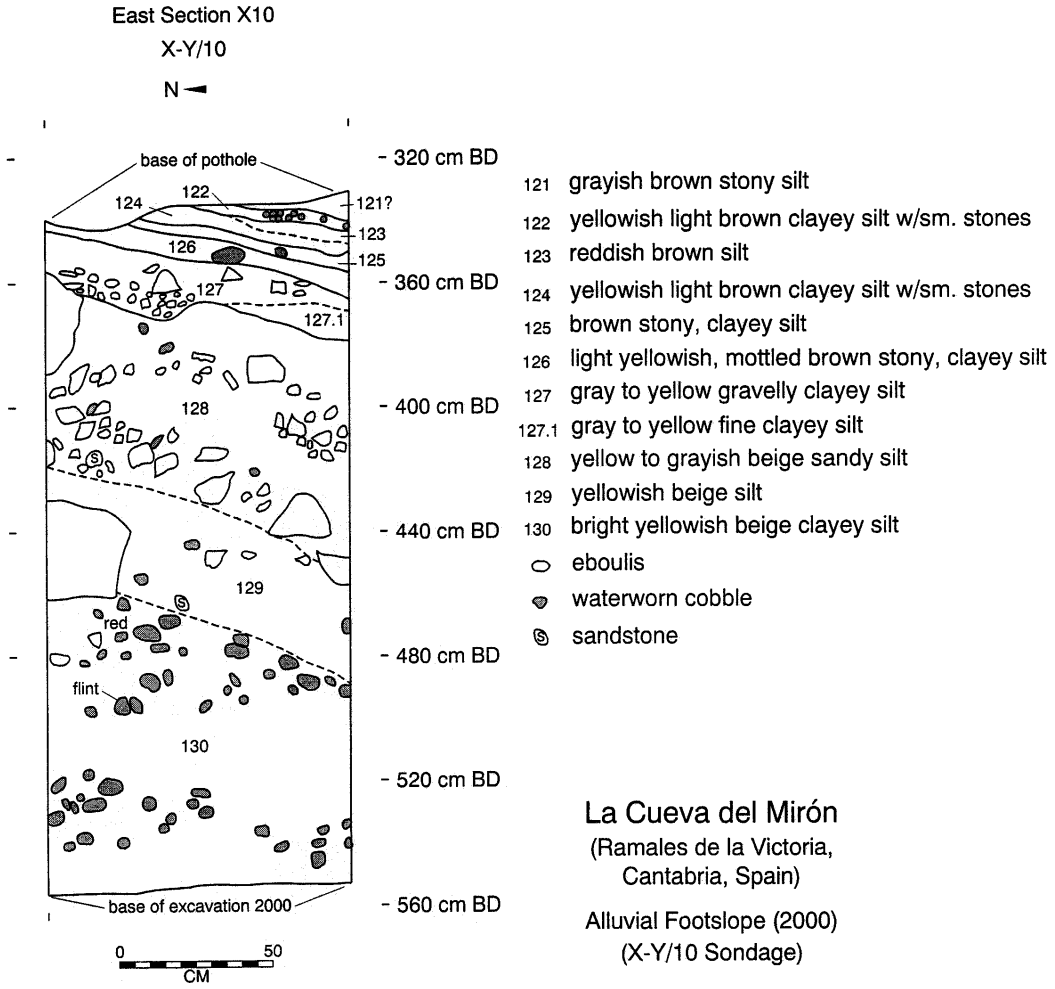

Figure 6 Stratigraphic section of the deep *sondage* at the vestibule rear

To avoid some of the problems that may have arisen by using many different ^{14}C laboratories at La Riera Cave, we decided to run all El Mirón dates through the Geochron lab, based on its excellent track record in providing dates for the South Belgium Prehistoric Project directed by Straus and M Otte. Up until now, 51 determinations from El Mirón Cave have been done, to our knowledge making it the largest series of ^{14}C dates from any single prehistoric site in Spain (see Table 1). The determinations have been done on both charcoal and bone collagen, conventionally or by AMS. Calibrations have been run for dates back to about 20 kya using the latest available version of CALIB (Stuiver et al. 1998).

^{14}C CHRONOLOGY OF THE POST-PLEISTOCENE LEVELS

Discussion of post-Pleistocene ages is in terms of calibrated AD and BC (Figure 9). There are 2 ^{14}C dates of Medieval age: 1 from a charcoal-rich layer (Level IV) stretching from wall-to-wall across the inner cave. The other is from a large lump of charcoal that came from the ground surface at the rear of the vestibule, after modern dung and debris had been shovelled out. The inner cave date (11th–12th century AD) might refer to a period of insecurity in the region, when other indicators suggest that people often took refuge and cached valuables in caves. The vestibule date (14th–15th

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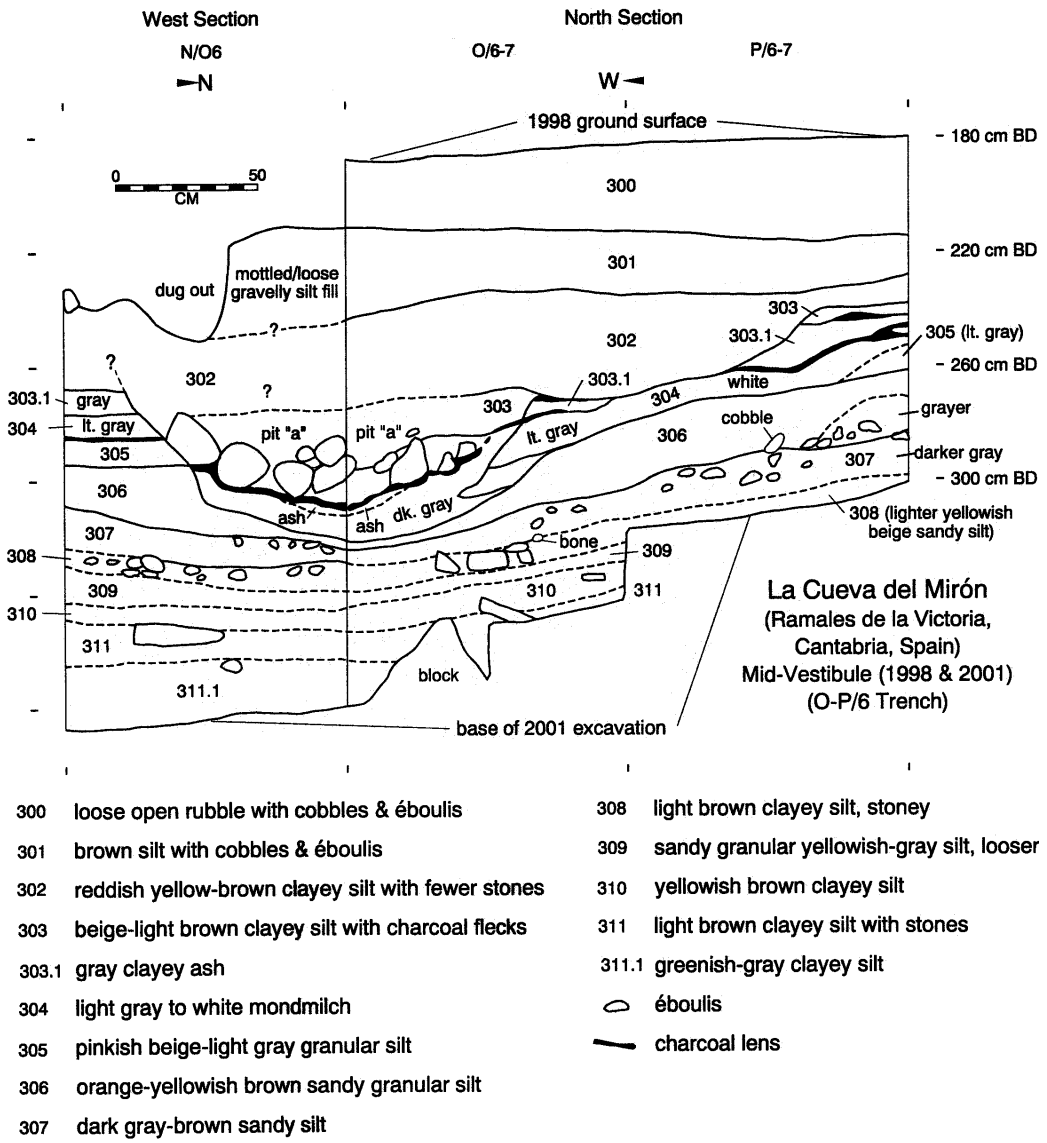

Figure 7 Stratigraphic section of the central part of the mid-vestibule connecting trench

century AD) attests to the continuing use of the cave by people and animals, as do the presence of the well-built stone cabin foundations in the outer part of the El Mirón vestibule.

The topmost, major prehistoric cultural level in the Cabin area (Stratum 3) is very rich in ceramics of Bronze Age type, domesticated animal remains (especially cattle and pig, as well as sheep/goat), and slag. It also yielded a copper pin and abundant evidence of *in situ* combustion, probably related (at least in part) to metallurgy. The date of ~2100 cal BC is consistent with an early Bronze Age, which, at any rate, is poorly distinguished from the Chalcolithic in this then culturally-peripheral region of the Iberian Peninsula. The succession of massive ash and charcoal lenses (possibly represented episodes of hygienic straw- and dung-burning) and pits of various sizes, contents, and probably functions that make up Strata 4–7 testify to intensive human occupation and animal stabling in

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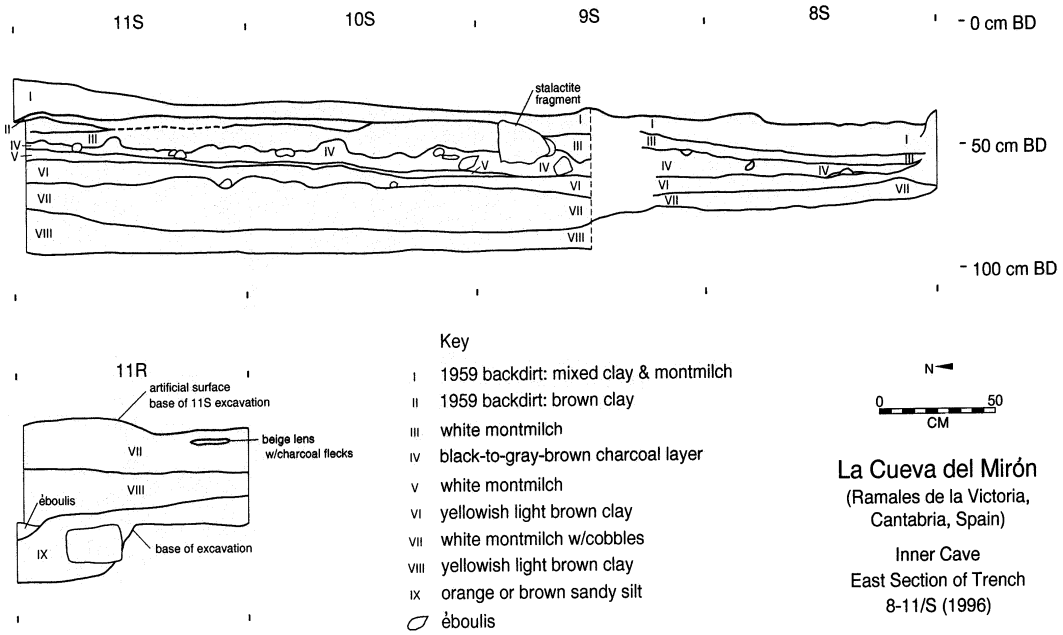

Figure 8 Stratigraphic section of the inner cave trench (not shown in Figure 3)

the El Mirón vestibule during Chalcolithic times. The temporally diagnostic stone arrowheads and ceramics are validated by dates centered on about 2500 cal BC. The abundance of pitting in these levels probably explains the stratigraphic inversion of GX-22130 and 24460.

Again, the significance and timing of the transition between the Neolithic and Chalcolithic in the Cantabrian region are still poorly defined (hence, the significance of such modem excavations as those at El Mirón or Pareko Landa in nearby central Vizcaya [Aguirre et al. 2000]). The Neolithic range of levels (10–8 and 303.3–303) at El Mirón dates between about 4600 and 3500 cal BC. However, the top of the sequence is currently undated, probably leaving a gap of about 500 yr precisely at the time of the transition, although this might be partly filled by a date of about 3700 BC (GX-28211) on abundant charcoal from the base of a large pit possibly corresponding to Level 302. (The top of this crater-like, 50-cm deep feature may still have been in use in the Bronze Age, based on the presence of possible slag near its surface.) The basal Neolithic dates from El Mirón (GX-25856 and 23413) are among the oldest that are known from the northern slope of the Cantabrian Cordillera (Arias et al. 1999) and are particularly important as they are definitely associated with domesticated ovicaprines (J Altuna and K Mariezkurrena, personal communications). They also correspond to the very oldest dates for the construction of megalithic monuments in the region (Yarritu and Gorrochategui 1995; Serna 2000). Although there is no direct palynological evidence for agriculture at El Mirón, wheat grains first appear in Level 303 at about 4300 cal BC (MJ Iriarte and L Peña, personal communications). Cereal grain has also been positively identified at Kobaederra Cave in central Vizcaya and is directly dated to about 4200 cal BC (Aguirre et al. 2000). Other sites ^{14}C dated to about the same age lack ceramics and domesticated animals, but have double-bevel retouched lithic segments characteristic of the early Neolithic, with or without imported cereals [e.g., Herriko Barra in coastal Guipúzcoa; Pico Ramos Cave in coastal Vizcaya; Tarreón and Cubio Redondo caves—both the latter close to El Mirón [Mariezkurrena and Altuna 1995; Zapata 1995; Apellániz 1971; Ruiz and Smith 2001]).

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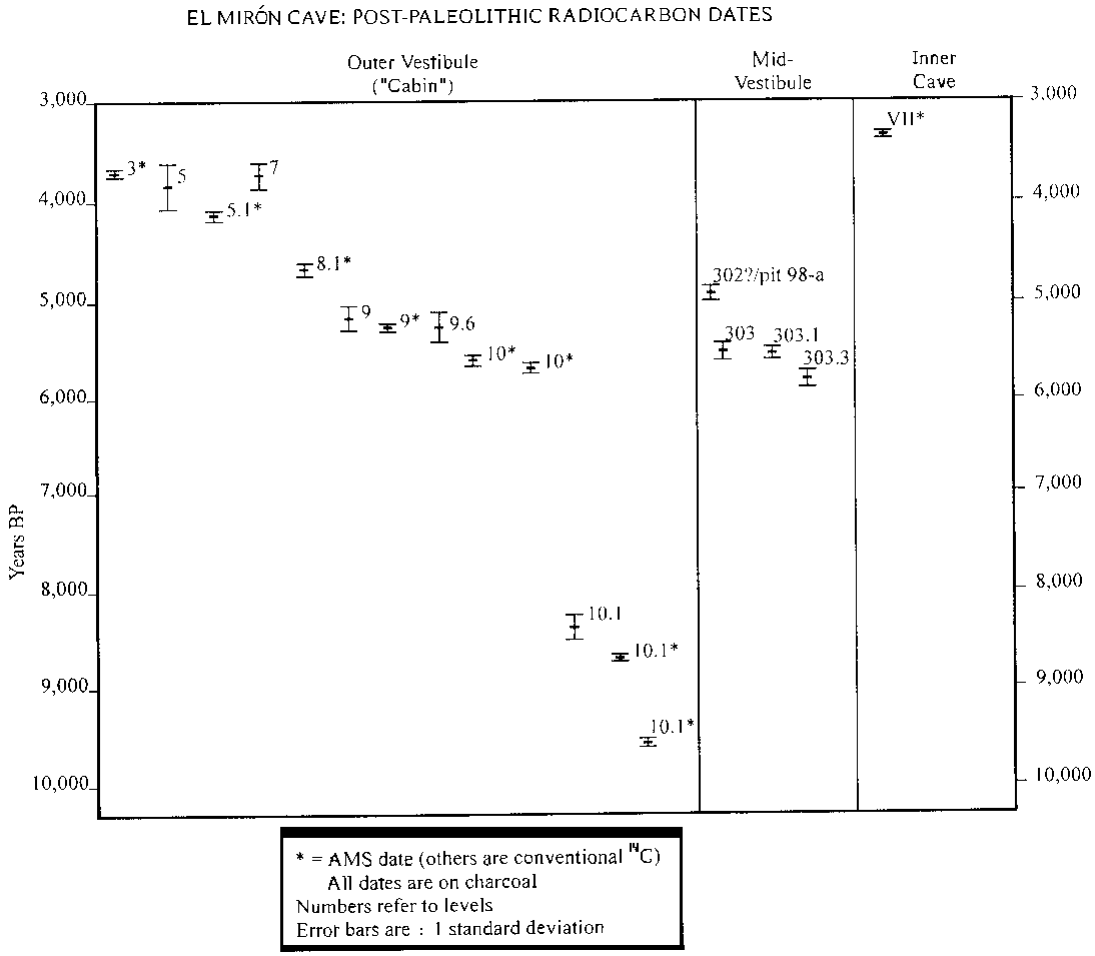

Figure 9 ^{14}C dates for the post-Paleolithic strata of El Mirón Cave (with 1 sigma)

There are depositional hiati between Strata 10.1 and 10 and between 11 and 10.1 in the Cabin area; similar gaps probably also exist in the mid-vestibule connecting trench. If the 3 ^{14}C dates are all correct, the 8–9-cm-thick Stratum 10.1 formed very slowly during the millennium between about 8900–7500 cal BC. There are only small numbers of culturally non-diagnostic lithic artifacts and faunal remains (none domesticated) in this layer and the same can be said for probably contemporaneous Strata 304 and 101/102 in the mid and rear vestibule, respectively. These scarce finds attest to ephemeral visits to the cave during early Mesolithic times, when human settlement was concentrated along the coast, notably at the Río Asón estuary (González Morales 1995; Straus and González Morales 2003). Other visits to the cave occurred in late Azilian times, at the Pleistocene–Holocene boundary, as attested by 2 AMS dates of about 10,700 cal BC on the same tooth from a breccia remnant adhering to the cave wall at the top of the inner cave slope.

^{14}C CHRONOLOGY OF THE PLENI- AND TARDI-GLACIAL LEVELS

Over half of the dates (29) from El Mirón cover the periods of the Solutrean, Magdalenian, and Azilian, which together make up the late Upper Paleolithic (Figure 10). Dates for the Upper Paleolithic

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are reported in terms of uncalibrated BP determinations, although calibrated ages are given in Table 1. The distinction between the final Magdalenian and the Azilian is fairly arbitrary in the absence of the characteristic flat-section Azilian harpoons at El Mirón, since small-backed stone points and thumbnail endscrapers (present at the site) can be found in both periods. There is no single and absolute date at which the transition occurs and indeed, even within a geographic region such as Cantabrian Spain, it can be time-transgressive between the Alleröd and Dryas III climatic phases. Stratum 305 in the mid-vestibule trench gave a date that is of late Azilian age (10,270 BP) but then there is a series of dates ranging between 11,650–11,950 BP for Strata 11.1, 306, and 102.1 in the outer, mid, and rear parts of the vestibule, respectively. A red ochre-stained pebble in 11.1 could be considered an Azilian diagnostic. In contrast, there is great clarity concerning a charcoal date of 12,970 BP very closely associated with a fragment of a circular-section, unilaterally-barbed harpoon diagnostic of the Upper Magdalenian in Cabin Stratum 12. (There is a date of 12,960 ± 50 [GX-29440] from Level 4 of La Fragua Cave at the present mouth of the Asón.) Strata 103–107 in the Corral area, although not yet dated by ^{14}C, probably pertain to this period. In general, however, the Upper Magdalenian is rather poorly represented at El Mirón but it and the Azilian have very abundant cultural remains (including harpoons pertaining to both periods) in Horno Cave at the base of the same mountain where Mirón is located and in El Valle Cave, about 8 km downstream along the Asón. These 2 sites have a total of 8 GX dates ranging between about 13,800–10,100 BP with 6 of them lying between 11,000–12,000 BP (Straus et al. 2002 a,b).

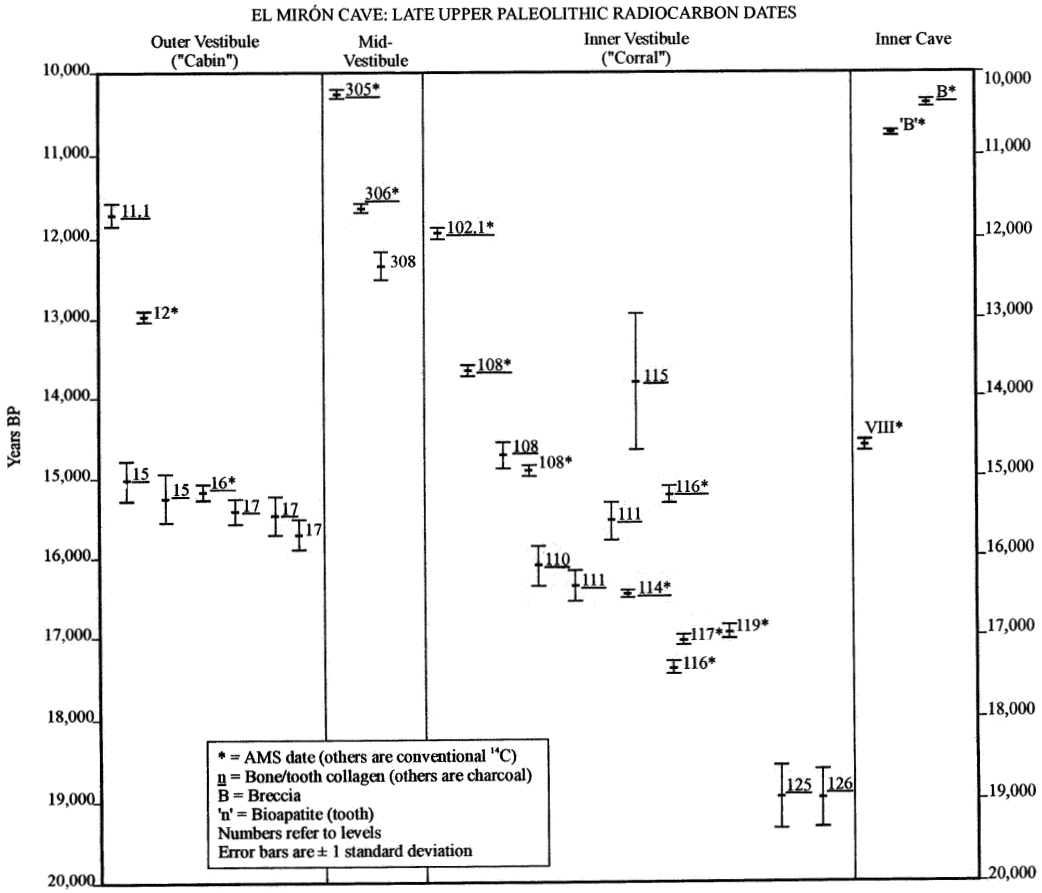

Figure 10 ^{14}C dates for the Late Upper Paleolithic strata of El Mirón Cave.

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The culturally-richest Paleolithic layers excavated so far at El Mirón pertain to the early–middle Magdalenian period. This period—variously subdivided into phases by different specialists—is also very well and richly represented in such classic sites as Altamira, El Castillo, El Rascaño, and El Juyo in central Cantabria, as well as at many sites in Asturias, Guipúzcoa, and Navarra. It seems to have been a time of high population density with many sites and frequent use of favored caves both for residence and for decoration. Over 40 directly AMS-dated rupestral paintings from Asturias and Cantabria (including all the dates from Altamira) pertain to the period between 17,000–13,000 BP uncalibrated, and most all of those actually date around 14,000–15,000 BP (Moure and González Sainz 2000 a,b; Fortea 2002). Engravings on a huge block that had fallen from the El Mirón ceiling at the vestibule rear were executed at this time, since the block fell atop a level (110) dating to about 16,000 BP, after which its inner face was engraved and finally covered over by a series of later Magdalenian levels (109–103) during a period of some 4000 yr (González Morales and Straus 2000). In addition, engravings (including one of a horse) on the cave walls adjacent to the Corral excavation area at the vestibule rear can also be reasonably attributed to the mid-Magdalenian period, based on their position (roughly equivalent to the height of an adult human arm) relative to ^{14}C-dated levels (García 2001).

The ^{14}C record for the early–mid Magdalenian in the Cabin excavation is straightforward and coherent when single standard deviations are considered: 6 determinations for Strata 15–17 lie between 15,000–15,700 BP. The situation is more complex in the Corral area. One determination (GX-23394: a conventional date on bone collagen from Stratum 115) is clearly "too young" in comparison to dates stratigraphically above and below it. However, with an exceptionally large, single standard deviation of 840 yr it could be as old as 15,480 BP at +2σ, which is more in line with the general trend for Strata 110–116. Organically and artifactually rich, Stratum 108 has 3 determinations from a single m^2 that are in stratigraphically descending order from 13,660–14,850 but the bone used for the topmost one could possibly have moved down from the rodent-burrow-ridden Stratum 107. While consideration of the standard deviations can eliminate some of the apparent inversions among the other dates from Strata 110–115, it is also true that all these levels are absolutely contiguous with no intervening sterile zones. In fact, the subdivision of this whole dark brown, artifactually-rich deposit is a relatively subjective affair, based largely on variations in the relative amounts and size of limestone spall (*éboulis*) versus purer silt, which may be local in nature. Intensive human activity may have been responsible for the date inversions. All of these levels are very well-endowed in backed bladelets, antler points (*sagaies*), bone needles, and faunal remains (notably of ibex and salmonids) with abundant evidence of fire, including a well-preserved hearth-and-pit complex in Stratum 108. The latter is precisely dated by AMS on a chunk of conifer wood charcoal (identified by L Zapata) to 14,850 BP. It is in this period (corresponding roughly to Cabin Stratum 14 and Corral Stratum 108) that human use was made of the dark inner cave, where blade cores and blades have been found associated with a charcoal sample dated to 14,620 BP at the base of a test pit dug below the floor of the 1950s trench. Cabin Stratum 17 (also extremely densely littered with stone and bone artifacts and faunal remains, as well as evidence of fire) can be approximately correlated temporally by ^{14}C with Corral Strata 110–116 in the 15,500–16,000 BP range. The seemingly "old" date of 17,400 BP (GX-29439) from Stratum 116 in V7b might be explainable by the fact that the charcoal sample comes from a hearth pit that might have been dug into or disturbed underlying layers. Approximate correlation of Cabin Strata 15/16 with Corral Stratum 108 is suggested by the discovery of the surface of a similarly distinctive, chocolate-brown, culturally-fertile deposit (312) at appropriate depths in a series of small test pits dug along the base of the mid-vestibule trench.

The base of the Magdalenian sequence, which has more use of local, non-flint raw materials (especially to make "archaic-looking" macrolithic tools such as sidescrapers, denticulates, and notches) dates to about 17,000 BP (Strata 117 and 119). A couple of Solutrean point fragments were actually found in Stratum 119, indicating that the transition between the normatively defined Solutrean and early Magdalenian industries occurred at right about this time. This is completely in line with what has been shown at other sites in the region such as El Rascaño, La Riera, and Chufin (Straus 1992).

The earlier parts of the chronostratigraphic sequence have so far only been revealed in the *sondage* dug below the bottom of the large pothole at the foot of the slope in the vestibule rear, not an ideal place for human habitation (due to wind currents) or preservation (due to erosion). Nonetheless, the results are encouraging as to the possibilities of finding Solutrean, early Upper Paleolithic, and Mousterian occupations elsewhere in El Mirón. The remnant Solutrean levels of 121–127) (partially cut into by the pothunters) are extraordinarily rich in foliate (including concave base), shouldered points, perforated shells and teeth, and fish remains, but have relatively few other artifacts. These layers, which are far less dark and organically rich than the overlying Magdalenian ones, are quite thin, so it is not surprising that Strata 125 and 126 have 2 statistically indistinguishable dates of 19,000 BP. This is a normal age for Solutrean occupations throughout Vasco-Cantabria and elsewhere in Iberia and southern France (Straus 1991, 2001) and corresponds to the onset of the Last Glacial Maximum. In calibrated form, this was about 22,000–23,000 yr ago.

^{14}C CHRONOLOGY OF THE INTERPLENIGLACIAL

Cultural and faunal remains of all kinds become far more scattered and scarce below Stratum 127 in a series of yellowish, light brown, colluvial, sandy, or clayey silts at the foot of the inner cave slope (Figure 11). However, flecks and chunks of charcoal are present, in association with occasional stone artifacts and bone fragments. From Stratum 128, a chunk of alder wood charcoal (identified by L Zapata) yielded a date of 27,580 ± 210 BP. Calibrated according to CALPAL 2001 by O Jöris (personal communication), this determination is equivalent to 29,332 ± 402 BC. This date corresponds radiometrically to early Gravettian levels (with *Noailles burins*) in the Basque cave sites of Antoliñako and Amalda, as well as to the culturally indistinct Level 7 at El Rascaño in the montane zone of the next river valley to the west of the Asón (Aguirre et al. 2000). It also overlaps with several early Aurignacian dates from Cueva Morín (Stuckenrath 1978), all of which have large standard deviations and could be "too young." The El Mirón Stratum 128 date, associated with no diagnostic artifacts, simply proves that humans did, at least occasionally, visit the cave during terminal Aurignacian or Gravettian times, as also suggested by *terminus ante quem* TL dates of about 26,000 BP on calcite covering engravings in the nearby cave of Venta de la Perra (Moure and González 2000a). Lion remains have been tentatively identified by J Altuna in Stratum 128.

Finally, the lowest level reached to date (Stratum 130) produced 2 flake denticulates, a few items of débitage and bone fragments, and a ^{14}C date on a chunk of conifer charcoal (possibly pine, according to anthracologist L Zapata) about 1 m below the Stratum 128 sample. The AMS determination of 41,280 ± 1120 BP is clearly within the terminal Mousterian time range, not only for Cantabria but also for Catalunya, the other region of Spain where a transition to the earliest Aurignacian is also proven to have taken place during about 40,000–38,000 BP uncalibrated (see Straus 1997, with references). Indeed, the Mirón date is very similar (within the respective standard deviations) to the AMS dates for the terminal Mousterian (Level 20) at nearby El Castillo Cave (Cabrera et al. 1996) and at the Asturian rockshelter site of La Viña, Level XIII basal (J Fortea 2001), as well as at the Catalan sites of Romaní and L'Arbreda (Straus 1997). The CALPAL 2001 calibrated version of the Mirón Stratum 130 date is 41,485 ± 1062 BC, implying a 1000–3000 yr error at about the time of

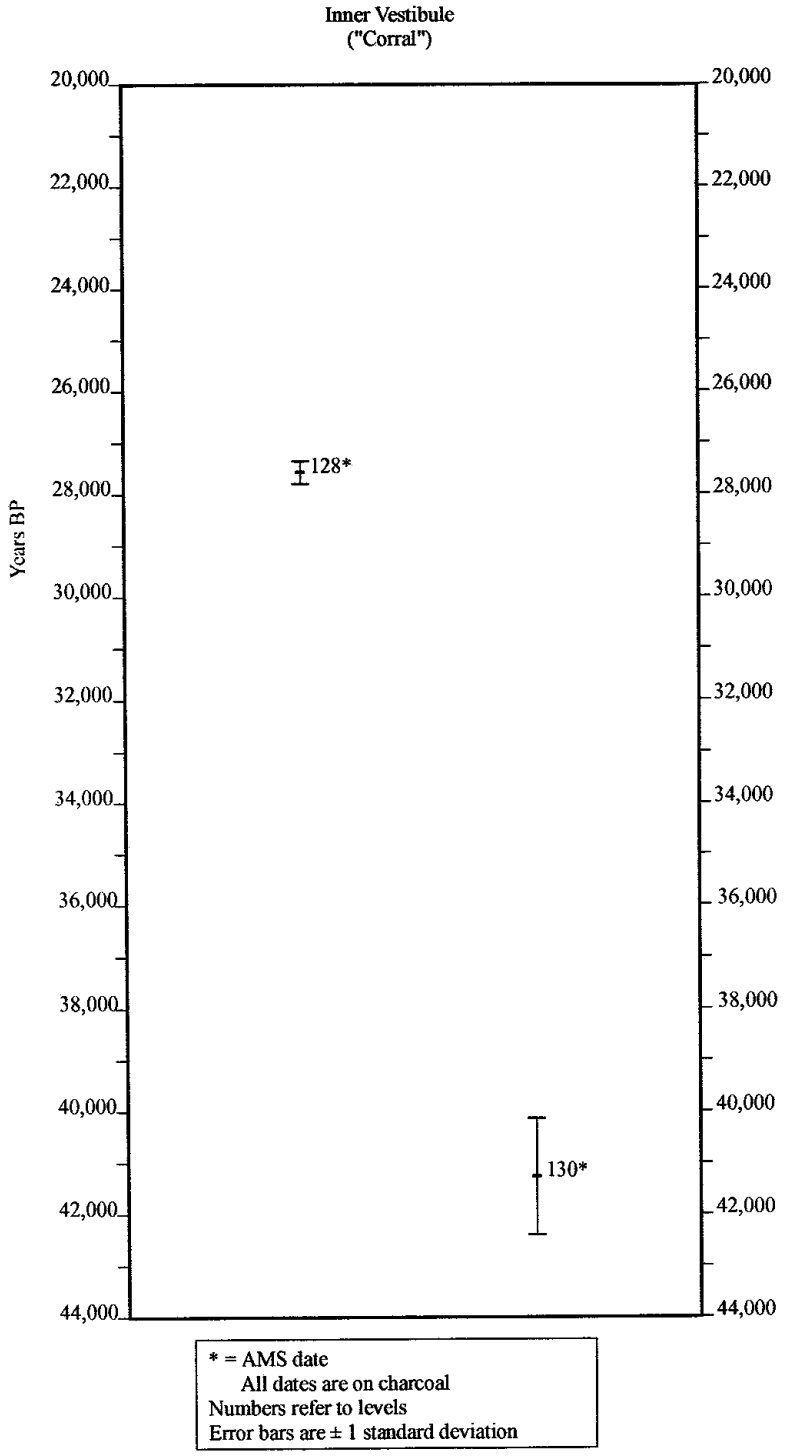

Figure 11 Pre-Solutrean ^{14}C dates for El Mirón Cave

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"the transition", which is in line with the comparison of ^{14}C and uranium-series dates from Romaní (Bischoff et al. 1994). Thus, El Mirón joins the growing list of Spanish sites that attest to the Middle–Upper Paleolithic transition and it is hoped that one day, in another, more densely occupied part of the cave, richer (and perhaps even older) Mousterian occupation layers will be found.

CONCLUSION

As it stands, the record of ^{14}C dates from El Mirón Cave is one of the largest, most complete, and most systematically developed in Europe. Despite some major depositional hiati—first realized thanks to the dating program—the cultural-historical/chronostratigraphic sequence in this cave is remarkably complete due to the attractive and strategic nature of the cavity itself, its stability, and relative lack of internal erosion. The El Mirón sequence is quickly becoming one of the new reference sites for the Middle–Upper Paleolithic transition, for the late Upper Paleolithic, and for the post-Pleistocene prehistory of Cantabrian Spain. The participation of the Geochron labs is integral to the success of the El Mirón excavation and to that of other associated research projects in the Río Asón Basin. Use of a single, high-quality dating lab allows for strict comparability among levels and sites. The high standards of professionalism at Geochron we all owe to a great scientist, Hal Krueger, whose memory we salute.

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