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RADIOCARBON DATES FROM THE MAMMAL FAUNA OF CRYSTAL CAVERNS, EL DORADO COUNTY, CALIFORNIA

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ABSTRACT. Dates from the mammal fauna of Crystal Caverns, El Dorado County, California confirm that it is a Pleistocene deposit from the Last Glacial Maximum. Results indicate it is similar in age to other comparable California caves and has a high degree of time averaging.

KEYWORDS: California, cave, date list, radiocarbon dating.

BACKGROUND

The late Pleistocene fauna of California is primarily known from lower elevation sites in southern California such as the La Brea tar pits and nearby localities (e.g., Harris 1985; Jefferson 1991), or the San Francisco Bay Area (e.g., Stirton 1939; Savage 1951). Higher elevation sites are less well known and are primarily represented by a handful of cave sites in the Cascade Range and the western foothills of the Sierras (Figure 1) that are characterized by having predominantly living mammals in combination with the extinct shrub ox (*Euceratherium collinum*), as well as localities possessing only extant fauna (Jefferson 1991). Of these sites, three have been successfully dated in recent years: Samwell Cave (approx. 19,960–19,960 ^{14}C age; Feranec et al. 2007), the lower chamber of Potter Creek Cave (approx. 17,150–12,400 ^{14}C age; Feranec 2009), and Hawver Cave (approx. 18,420 ^{14}C age; Bonde 2013), all falling within the Last Glacial Maximum. Here we report the first dates for a new late Pleistocene fauna in a long-known cave system in the Sierra Foothills and provide a preliminary faunal list.

Crystal Caverns is located in El Dorado County, California. It has been known as Limestone Cave, Crystal Cosumnes Cave, Cosumnes Crystal Cave, and Crystal Cave, and its location has been known to the public since at least 1856 (Lange 1952). Crystal Caverns (Figure 2) is located on the north side of the Middle Fork of the Cosumnes River in the Mother Lode region. It is different from Crystal Cave in Sequoia National Park in Tulare County, California. The cave is formed within limestone of the Calaveras Complex and was surveyed in 1952 by the Stanford Grotto chapter of the National Speleological Society (Lange 1952). A fossil assemblage was excavated by B. Garrison and D.A. Lawler in 1991 and reposited at the University of California Museum of Paleontology (UCMP). All specimens were collected on the floor of a chamber approximately 70 m from the main entrance of the cave (UCMP Locality V91012). Fossils were collected from an approximately 15–20 cm thick deposit of fine gravel and oxidized yellow-red clay 60 × 15 cm in areal extent. This deposit was capped by a 5–10 cm thick flowstone. More than 3300 fossil specimens were recovered from this single deposit, the vast majority of which (> 2600) are mammals (see Table 1). Additional vertebrate taxa include hundreds of fish bones, and rarer amphibians, lizards, snakes,

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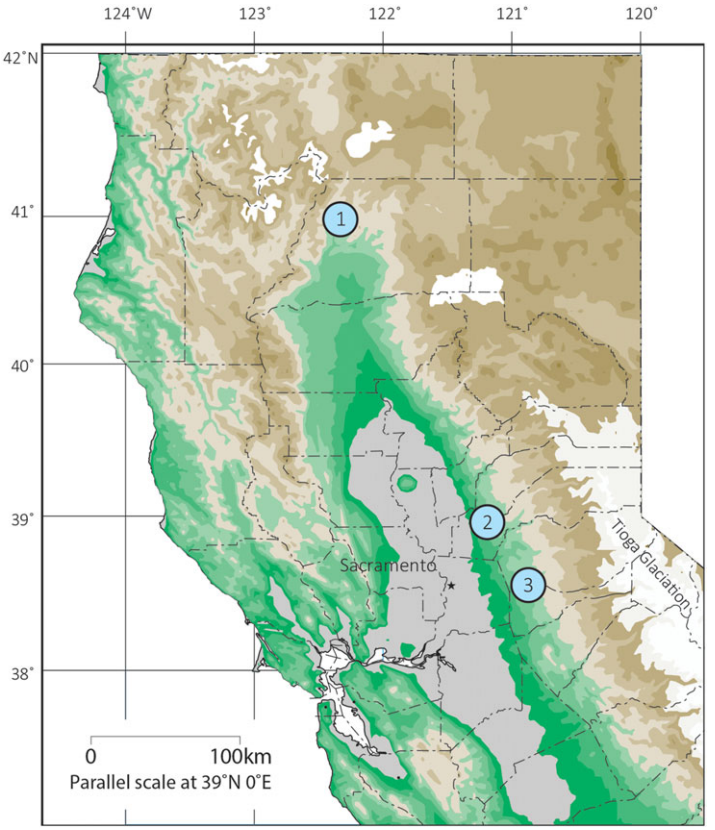

Figure 1 Map showing the location of dated late Pleistocene cave sites containing vertebrate faunas and the extent of the Tioga Glaciation in the Sierra Nevada (after Moore and Moring 2013) and approximate extent of glaciation in northern California (after Porter et al. 1983). (1) Samwell [Samwel] and Potter Creek Caves (UCMP localities 1008 and 1055). (2) Hawver Cave (UCMP locality 1069). (3) Crystal Caverns (UCMP locality V91012).

strigiform owls, falconiform raptors, quail, and other birds. Gastropods and natural casts of diplopod millepedes complete the fauna. Assignment of specimens to taxa were made based on direct comparisons with UCMP's Late Pleistocene fossil collections, including the type series of *Euceratherium collinum*, and modern comparative collection.

METHODS

Five bone specimens from the UCMP collections were sampled using a Dremel tool cutting wheel: two *Euceratherium collinum* pedal elements (UCMP 271175, 229356), an *Odocoileus hemionus* left dentary (UCMP 224550) and metatarsal (UCMP 224981), and another large mammalian bone fragment (UCMP 224984). Following mechanical surface cleaning, samples of ~200 mg of bone were crushed to mm-sized powder, decalcified overnight in 1N HCl at room temperature, gelatinized overnight at 60°C and pH 2, and ultrafiltered to select a high molecular weight fraction (>30kDa). ^{14}C was measured at the W.M. Keck Carbon Cycle Accelerator Mass Spectrometer Facility at the University of California, Irvine.

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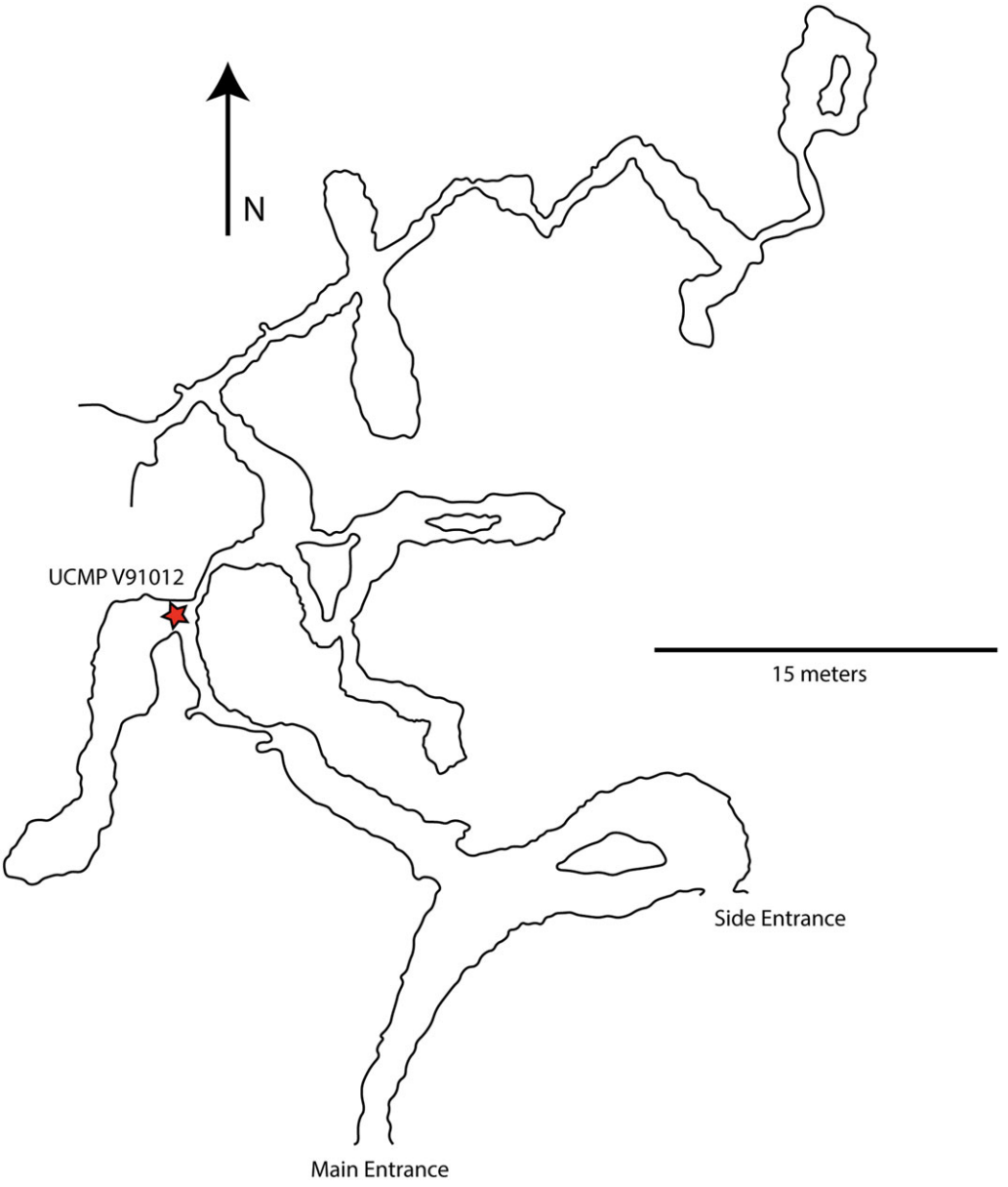

Figure 2 Diagrammatic representation of the Crystal Caverns cave system showing the location of the fossil deposit based on W.S. Wise's drawing from Lange (1952).

RESULTS AND DISCUSSION

Of the five samples, three yielded sufficient ultrafiltered collagen for measurement and produced ^{14}C dates, ranging from 26,090 ± 120 BP to 16,595 ± 45 BP (Table 2). The range of these dates suggests that the single Crystal Caverns deposit represents at least 10,000 years of time averaging. As a fluvial deposit it is likely that the assemblage is

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Table 1 Crystal Caverns mammalian taxonomic list.

Taxonomic identification	UCMP voucher spec #
Artiodactyla	
Bovidae	
Euceratherium collinum	229356
Cervidae	
Odocoileus hemionus	224550
Carnivora	
Mephitidae	
Mephitis mephitis	225006
Spilogale sp.	225008
Mustelidae	
Martes americana	225009
Canidae	
Vulpes vulpes	225000
Lagomorpha	
Leporidae	
Lepus sp.	250382
Rodentia	
Aplodontiidae	
Aplodontia rufa	224506
Cricetidae	
Neotoma sp.	225019
Peromyscus sp.	225110
Geomyidae	
Geomys sp.	225130
Sciuridae	
Otospermophilus sp.	225086
Tamiasciurus sp.	225085

also spatially averaged and that some portion of the fauna was washed in. Many of the fossils at the site, including those sampled here, exhibit rodent gnaw marks. Based on the size and shape of the gnaw marks it seems unlikely they were from a woodrat and were probably from a smaller rodent. These indicate that bones were exposed on the surface for at least some period of time in a dry state and are consistent with the assemblage being redeposited.

All the dates from V91012 fall within the broad span of the Last Glacial Maximum (LGM) from approximately 27–15 kya, corresponding to the Tioga glaciation in the Sierra Nevada (Moore and Moring 2013). During this time northern California climate was generally cooler and drier (Street et al. 2012) and glaciated. Crystal Caverns overlaps in age with the more northerly late Pleistocene cave sites of Potter Creek, Samwell, and Hawver. Like these other caves, radiocarbon dates indicate time-averaging of the fauna, although that may be desirable for some types of evolutionary studies (e.g., Blois et al. 2008).

Crystal Caverns is located at an elevation of approximately 610 m, whereas Potter Creek Cave and Samwell Cave are at about 460 m (Feranec et al. 2007; Feranec 2009), and Hawver Cave

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Table 2 Radiocarbon concentrations are given as fractions of the Modern standard ($F^{14}C$) and conventional radiocarbon age, following the conventions of Stuiver and Polach (1977). Collagen stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) were measured to precisions of <0.1‰ and <0.2‰, respectively, using a NA1500NC elemental analyzer/Finnigan Delta Plus isotope ratio mass spectrometer.

UCIAMS #	UCMP #	Species ID	$F^{14}C \pm 1\sigma$	^{14}C age (BP) $\pm 1\sigma$	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C/N ratio
219222	271175	*Euceratherium collinum*	0.0388 ± 0.0005	26,090 ± 120	–20.5	4.1	3.3
219223	224550	*Odocoileus hemionus*	0.1267 ± 0.0007	16,595 ± 45	–19.9	4.1	3.3
219224	229356	*Euceratherium collinum*	0.0757 ± 0.0006	20,730 ± 70	–19.7	4.0	3.2

sits at 393 m (Bonde 2013). Based on the elevation and faunal composition, the area around Crystal Caverns during the Pleistocene was likely wet (at least on a local scale) and forested. Both today and in the past, elevational gradients and their co-variation with temperature and precipitation act as a driver of community-structuring and species richness (e.g., Badgley and Fox 2000; Sundqvist et al. 2013). Together, these caves represent a snapshot of a California Last Glacial Maximum fauna similar to the modern and distinct from the better known more coastal and lower latitude faunas. Importantly, the relative contemporaneity of the sites in an area of high modern mammalian endemism, i.e., a biodiversity hotspot (Davis et al. 2008) means these cave sites present a unique window into the evolution of this modern species richness. Establishing the age range of the Crystal Caverns assemblage adds a new and rich fauna to the small set of dated Last Glacial Maxima paleontological sites in the foothills of the Sierras.

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