Biological and Cultural Evidence from Prehistoric Human Coprolites

The diet of prehistoric Great Basin Indians can be reconstructed from desiccated fecal material.

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Ancient organic material may be preserved when bacterial decay is partially or wholly inhibited by certain environmental conditions and processes, such as refrigeration in permafrost, chemical action in peat bogs, continuous immersion in seawater, and desiccation in arid climates. Conditions of extreme dryness in Egypt, Peru, Mexico, and the American West have preserved archeological material that includes human corpses in the form of natural "mummies" and other usually perishable organic material (*1, 2*).

One of the most mundane, but at the same time interesting and informative, types of paleobiological material is animal and human excrement preserved in the form of coprolites (from the Greek *kopros*, meaning dung, and *lithos*, meaning stone). There are two "types" of ancient coprolites: mineralized animal excrement of great geological age (*3*) and prehistoric human and animal feces preserved in an organic state. A review of the literature suggests that, although ancient coprolites preserved by frost or desiccation occur more frequently than one would suppose, there has been very little systematic collecting, and practically no detailed analysis, of this unusual and potentially informative biological material. Food habits of ancient and modern animal species have been studied by analysis of excrement preserved through desiccation, but, for the most part, analyses of ancient human fecal material preserved in various archeological sites covering a long span of man's occupation in arid regions in the Old World and the New have been undertaken only in order to investigate the possible presence of pathogens, parasites, and other organisms common in the human intestinal tract. The food items contained in these feces have rarely been identified, and in no instance known to us has there been an adequate reconstruction, through coprolite analysis, of the composition, potential fuel value, efficiency of energy transfer, and possible physiological effects of ancient human dietary regimes (*4*). The archeological, biological, and biomedical information potentially available through analysis of human excrement is at present almost wholly unexplored. Only recently have archeologists and their colleagues developed analytical techniques that yield adequately controlled data which can be used in reconstructing the diet and eating practices of ancient peoples.

Archeologists who attempt to reconstruct economic and dietary practices of prehistoric populations usually have no recourse other than to make inferences about hunting or collecting activities from the artifacts and animal bones recovered from open-air occupation sites, and, by extrapolation, about the nature of the dietary economy and the proportions of meat, seeds, tubers, and other foodstuffs in the diet (*5, 6*). This procedure is extremely crude, and it may be misleading, yielding erroneous deductions (*7*). When normally perishable food debris —such as seeds, plant remains, tubers, feathers, skin, and animal bones—is preserved by dry conditions in open-air, rock-shelter, and cave sites such as those found in the American Southwest and Great Basin, the archeologist is in a much better position to identify and determine the relative importance of the animals and plants used for food (*6, 8*).

There is rare evidence of other kinds concerning ancient meals—such as accounts of a repast of the Aztec emperor Montezuma (*9*); the dried remains of an Egyptian noblewoman's funerary feast, found in dishes discovered in a tomb of the IInd dynasty at Saqqara (*10*); and the stomach contents of corpses preserved in peat bogs in Europe (*11*)—but the best evidence of the amount and kinds of food eaten by an individual at a single meal in ancient times is provided by preserved fecal material.

Earlier Coprolite Research

One of the first examinations of prehistoric human fecal material was carried out by Wood Jones in the course of his studies on the paleopathology of Egyptian mummies (*12*). An early investigation of fecal material from an American archeological site was made by Young, who found sunflower seeds (*Helianthus*) and fragments of hickory shell in coprolites from Mammoth Cave and Salts Cave, Kentucky (*13*). As early as 1898, Strauss devised clinical fecal-analysis techniques that were similar to the rehydration analysis techniques developed 70 years later for the study of archeological specimens (*14*).

In 1912, Lovelock Cave, a large and important archeological site in west-central Nevada, was partially excavated by L. L. Loud of the University of California, Berkeley, who discovered that the dry trash deposits in the cave contained an abundance of fecal pellets produced by cave-dwelling animals and humans (*15*). Some of the human coprolites were broken apart and inspected by Loud, who remarked: "The human excrement in the cave reveals, on the part of the ancient inhabitants, an incredibly coarse diet of seeds, hulls, and tough plant fibers. Some of the excrement was over two inches in diameter."

Loud's perfunctory examination of the Lovelock human coprolites provided a tantalizing glimpse of the food habits of the ancient inhabitants of Lovelock Cave, but this promising line of research was not continued.

In the 1930's, vegetal material contained in sloth (*Nothrotherium*) dung found in Muave and Rampart caves, New Mexico, and in Gypsum Cave, Nevada, was examined, and plant spe-

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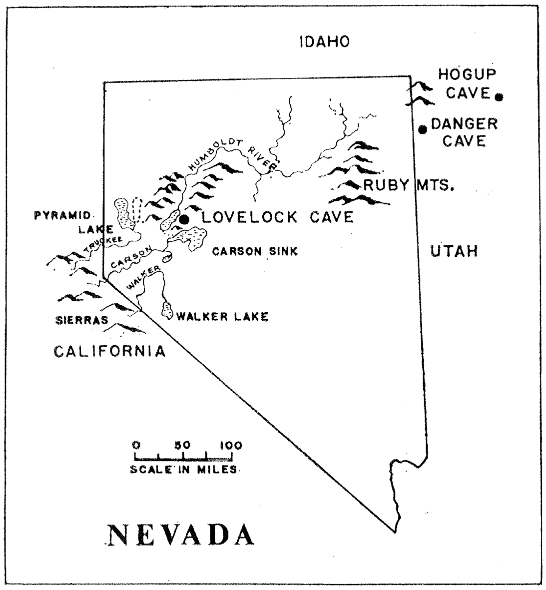

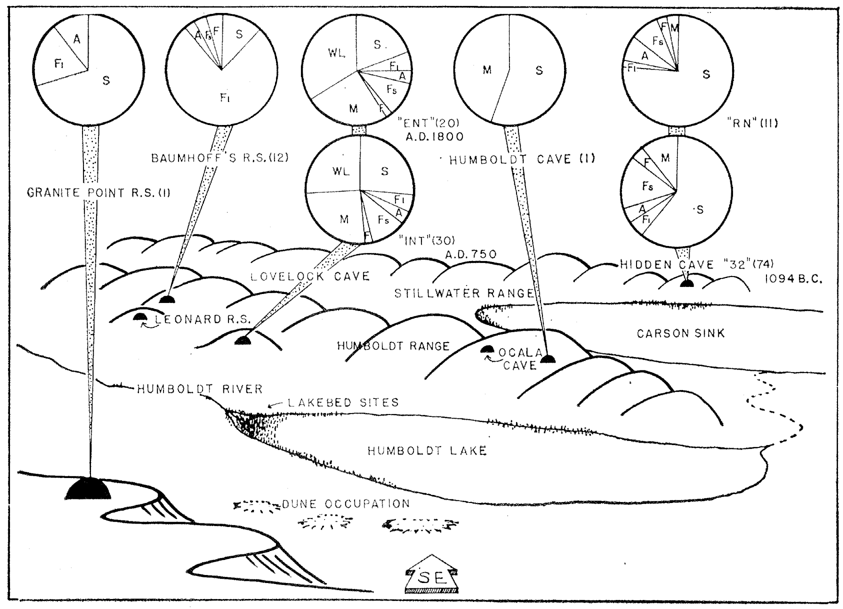

Fig. 1 (left). Map of Nevada showing archeological cave sites. Fig. 2 (right). Diet of prehistoric man in the Humboldt Lake–Carson Sink area, Churchill County, Nevada, as indicated by coprolite analysis. The seven sector diagrams illustrate the approximate percentages of food items found in coprolites from five lakeshore caves. The caves are shown diagrammatically in an oblique view, looking southeast into the Humboldt-Carson sinks of western Nevada. *A*, avian; *F*, mammals; *Fi*, fibers; *Fs*, fish; *M*, miscellaneous; *S*, seed; *WL*, weight loss; "*ent*," sample from cave entrance; "*int*," sample from cave interior; *R.S.*, rock-shelter; *RN*, Hidden Cave "rat nest"; "*32*," 32-inch midden deposit in the Hidden Cave site. Numbers in parentheses are total numbers of coprolites analyzed; the dates shown for the Lovelock Cave coprolites were obtained by the radiocarbon method.

cies consumed by the sloths were identified (*16*). Dung of *Neomylodon* was collected from caves in Argentina before 1890 (*17*). Human excrement from a dry rock-shelter in Kentucky (Newt Kash Hollow) was studied in detail by Volney Jones (*18*). The coprolites contained seeds of marsh elder (*Iva*), sunflower (*Helianthus*), and chenopods, as well as pieces of acorn and hickory nuts. Wakefield and Dellinger examined fecal material from the intestinal tract of a desiccated human body discovered in a bluff rock-shelter in Arkansas. A sample of the feces was examined by T. B. Magath, who found neither ova nor parasites. No microorganisms could be cultured, and bile tests gave negative results. Food items identified in the excrement included seeds of sumac (*Rhus*), and acorns (*19*). Similar examinations of food items contained in the viscera of mummified human remains were made by Wood Jones (*12*) and subsequently by Ruffer (*20*). The latter dissected the alimentary tract of bodies found in the cemeteries of Biga and Hesa, Egypt, and identified "melon seeds, grape pips, and the husks of barley." Prehistoric human excrement recovered by Junius Bird in the course of excavating the dry open-air midden of Huaca Prieta, an archeological site on the arid Peruvian coast, was examined in 1955 by Callen and Cameron (*21*). The food items included beans (*Phaseolus lunatus; Canavalia*), squash (*Cucurbita*), and the remains of various fish. In 1957 Fonner and Sperry reported results of their examinations of human and animal excrement from Danger Cave, Utah (*22*). They experienced some difficulty in differentiating between feces of bears and of humans, but the human origin of some of the excrement was indicated by the presence of deer or antelope hair, milled seeds of "burroweed" (*Alienrolfea*), bulrush (*Scirpus*), and minute pieces of bone.

The first thorough analyses of human fecal material from archeological sites were performed by Callen and his associates at McGill University, Montreal, Canada (*23*). Callen analyzed a large number of coprolites collected by R. S. MacNeish from the middens of stratified caves in Tamaulipas and the Tehuacán Valley, Puebla, Mexico. The food remains in the Tehuacán coprolites included beans (*Phaseolus*), squash (*Cucurbita*), maize (*Zea*), maguey (*Agave*), chili pepper (*Capsicum*), foxtail millet (*Setaria*), and fragments of the bones of mice, lizards, snakes, and deer. Some of the Tehuacán coprolites also contained feathers, eggshell, and bird bones.

Feces from archeological sites occupied during the Middle Ages in Europe and from sites in Israel have been examined for the presence of endoparasites commonly found in humans and animals (*24*). Research on coprolites found in North American archeological sites during the last decade includes palynological studies of fecal specimens from sites in Glen Canyon, Utah, and analysis of fecal pellets from Mesa Verde National Park, Colorado. The Mesa Verde specimens contained squash, corn, beans, eggshell, hair, bone, and seeds of wild or uncultivated plants (*25, 26*). In 1965, Watson and Yarnell examined a sample of coprolites from Salts Cave, Kentucky, verifying the earlier findings of Young (*13*) and identifying 14 additional food plants (*27*).

Coprolites from Danger Cave, Hogup Mountain Cave, and Bear River Cave, Utah, have been analyzed recently by Fry (*28, 29*). Forty-three coprolites from Danger Cave represent a time-range of occupation from the 9th millennium B.C. to about A.D. 1800. Food remains found in these specimens include chenopods (*Allenrolfea*), bulrush (*Scirpus*), epidermal tissues of prickly pear cactus (*Opuntia*), and a quantity of antelope hair (*Antilocapra americana*). Coprolitic and archeological evidence from Danger Cave is interpreted as indicating that the subsistence pattern based on exploitation of foods secured from the arid desert biome persisted without significant change for some 10,000 years. Coprolitic, archeological, and ecological evidence from Lovelock Cave, located about 300 miles (480 kilometers) southwest of Danger Cave, and data from other cave and rock-shelter sites in western Nevada, suggest that some of the prehistoric inhabitants of the western Great Basin subsisted primarily on lacustrine resources obtained from lakes and marshes formed in the catchment basins of the Humboldt, Truckee, Carson, and Walker rivers (*30*) (Fig. 1). The contents of the Danger Cave and Lovelock Cave coprolites indicate the complexity of cultural adaptations that occurred in different local environments in the extensive Great Basin physiographic province of the American West (*31*). Coprolite analysis can be used to investigate the hypothesis that a single, unchanging climatic regime has prevailed in the Great Basin for the last 10,000 years, as is indicated by evidence from archeological sites in western Utah. A rather different impression of Great Basin cultural and climatic events may be gained from study of the archeology and climatology of west-central Nevada, as demonstrated through palynological studies of cave fills and the contents of the Lovelock Cave coprolites. These studies indicate that the prehistoric inhabitants of the lakeside caves made primary use of lake marsh plants for food and for making many cultural objects (*32*) (Fig. 2).

Lovelock Cave Coprolite Research

Lovelock Cave (Fig. 3) lies 4240 feet (1270 meters) above sea level, on the north flank of the western part of the Humboldt Range in Churchill County, Nevada, and is about 2 miles to the south of, and 300 feet above, the bed of a large brackish water "sink" which formed at the outlet of Nevada's longest river, the Humboldt. The dome-shaped chamber (Fig. 4), which is about 160 feet long and 40 feet wide, developed in a slump fold of an uplifted limestone formation. The geological history of Lovelock Cave is not well understood at present, but it is apparent that the cavern did not become available for human occupancy until the waters of Lake Lahontan receded to below 4200 feet above sea level (*33*). Leonard Rockshelter (*34*), which provides some of the oldest certain evidence of ancient human occupation in Nevada (about 9000 B.C.), lies about 8 miles north of Lovelock Cave and at a higher elevation. Human occupation of Lovelock Cave probably began between 2000 and 3000 B.C., and the cavern gradually filled with an accumulation of bat guano, massive rockfall, roof scalings, cultural material, windblown sand, dust, rat-nest remains, and other debris that eventually formed a deposit more than 15 feet deep. Coprolitic and archeological material collected from the cave during recent investigations suggests that occupation of the outer rock-shelter continued until as recently as A.D. 1800 (see *30, 35, 36*), but it appears that the interior of the cave was less used during the latter part of this period, since the uppermost strata consisted almost entirely of a deposit of bat guano, from 4 to 6 feet thick. In 1911, commercial mining of the guano deposit brought to light abundant archeological remains buried in the powder-dry cultural strata. This discovery led to Loud's excavations of 1912, and to his later work with Harrington in 1924. Collections from the site are housed in the Lowie Museum (Berkeley) and the Heye Museum of the American Indian (New York) (*37*). No further investigations were conducted in the cave until 1950, when a University of California field class in archeology visited the site and collected a number of coprolites from the surface layer and from mounds of disturbed refuse

Fig. 3. Lovelock Cave (site NV-Ch-18), Churchill County, Nevada, looking south.

Fig. 4. Interior chamber of Lovelock Cave.

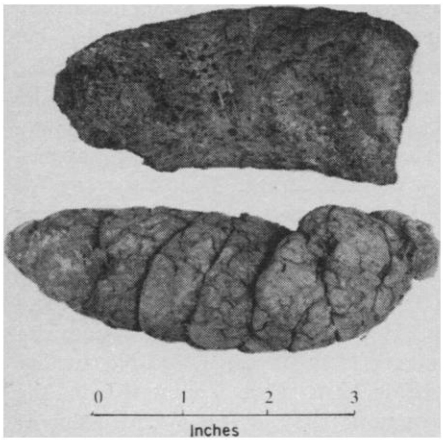

Fig. 5. Human coprolites from Lovelock Cave. Weight: top specimen, 59.6 grams (note the black *Scirpus* seeds); bottom specimen, 54.8 grams.

(Fig. 5). Fifty-one of these coprolites were analyzed in 1956 by Roust (*38, 39*), who separated some of the coprolite components by passing the crushed dry specimens through graded geological screens. Roust was able to identify many of the foods eaten by the prehistoric residents of the cave, but the coprolites had been collected from disturbed deposits and could not be dated. In 1965, additional samples were collected from two undisturbed remnants of the midden. These separate lots, called the "entrance" and "interior" coprolites, provided samples for radiocarbon dating and constituted two age-differentiated groups of coprolites, whose dietary constituents could be compared. Radiocarbon dating of an "entrance" coprolite (UCLA 1071-E) gave an age of 145 ± 80 years, and dating of one of the "interior" coprolites (UCLA 1071-F) gave an age of 1210 ± 60 years. The two lots of fecal material therefore reflect aspects of the prehistoric local diet and of ecological conditions at approximately A.D. 1800 and A.D. 740, respectively.

Examination of 20 "entrance" and 30 "interior" coprolites was made in 1965 by R. Ambro and R. Cowan, graduate students in the department of anthropology, University of California, Berkeley, using a modification of the coprolite rehydration technique developed by Callen (*40*). The coprolites are softened, and most of the soluble organic constituents are reconstituted, by immersion for 48 to 72 hours in an aqueous solution of trisodium phosphate (Na_3PO_4). The trisodium phosphate cleans and partially restores the seeds, vegetal tissues, meat fragments, and other delicate remains such as parasites, feathers, and insects (*41*). The rehydrated coprolites are passed through a screen (mesh, 1 millimeter), and the residuum is dried and sieved through a series of graded geological screens. The coprolite constituents are then sorted under an illuminated magnifier or stereoscopic microscope into general categories, such as seeds, fish bone, feathers, hair, plant remains, and charcoal (Fig. 6). Unidentified items are mounted in glass microscope slides or are stored in alcohol or formalin in 1-dram vials, which are subsequently distributed to various specialists in the biological sciences for study, identification, and analysis.

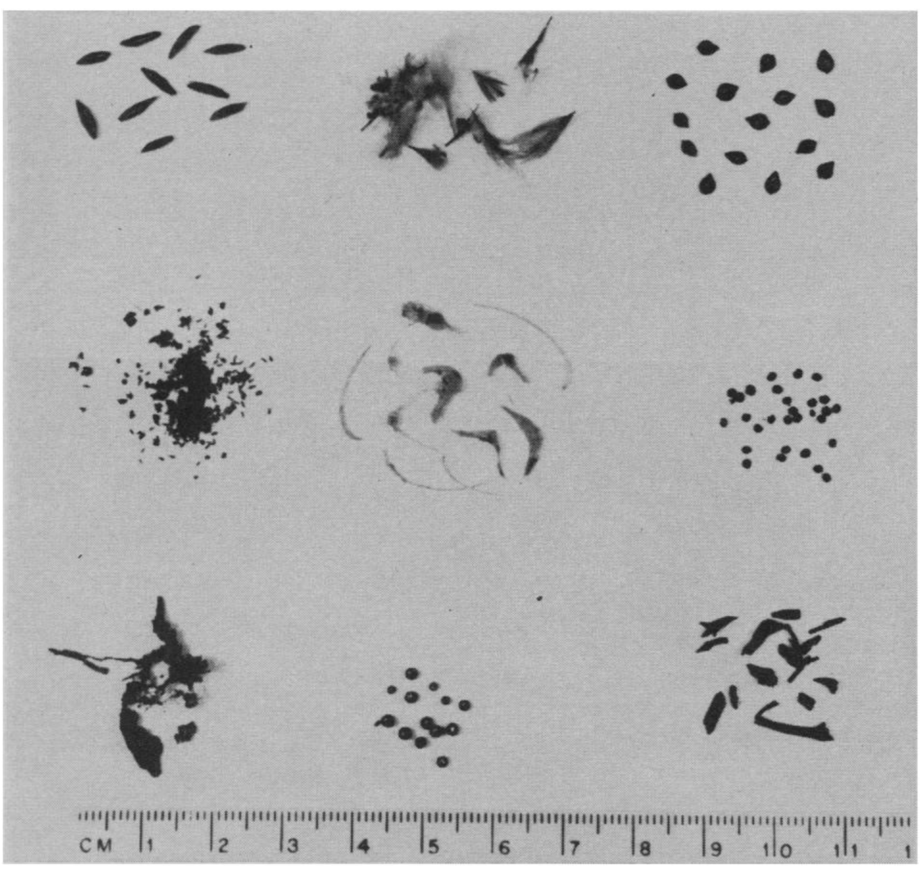

Fig. 6. Typical constituents of coprolites from Lovelock Cave. (Top row, left to right) Seeds of *Elymus triticoides*; down feathers of *Fulica americana*; seeds of *Scirpus robustus*. (Middle row, left to right) Seeds of *Typha latifolia*; bones of *Gila* (=*Siphateles) bicolor*; seeds of *Suaeda depressa*. (Bottom row, left to right) Plant fiber (probably *Typha* or *Scirpus*); unidentified translucent spherical objects; wood charcoal from seed or fish parching.

During 1966 and 1967 we and our colleagues continued coprolite research and identified many specific foods contained in the feces (*42, 43*). Follett (*44*) examined ichthyological remains found in the coprolites and identified them as the scales, bone, and skin of tui chub (*Gila* [*Siphateles*] *bicolor*), Tahoe sucker (*Catostomus tahoensis*), and Lahontan speckled dace (*Rhinichthys osculus robustus*), which are presumed to have been caught in Humboldt Lake.

Ambro and Cowan (*30*) found that about half (by weight) of the contents of the "entrance" coprolites consisted of parched bulrush (*Scirpus*) and cattail (*Typha latifolia*) seed. The latter had been prepared for human consumption by exposing the cattail down or bristles to controlled flame, a culinary technique known to the Northern Paiute of central Nevada (*15*). Other seeds eaten by the prehistoric residents of Lovelock Cave include *Mentzelia, Elymus, Suaeda, Atriplex,* and *Panicum*. The plant remains subsume six genera: *Typha, Distichlis, Scirpus, Elymus, Suaeda,* and *Phragmites* (*45*). Roots and fragments of aquatic tubers are also present in many of the "entrance" coprolites (*46*). Pollen grains represent the above-named plants, but dozens of the Lovelock coprolites are composed almost entirely of cattail pollen, which may have been baked in a pit oven prior to ingestion (*43*).

Douglas (*47*) found that the coprolites contained loose hairs of antelope,

Table 1. Occurrence of constituents in 50 Lovelock Cave coprolites.

Constituent	"Entrance" specimens ($n = 20$)	"Interior" specimens ($n = 30$)
Plant		
Pinus monophylla, seeds	1	3
Equisetum sp., spores		1
Typha latifolia, seeds, fiber	19	16
Distichlis stricta, seeds, fiber	5	6
Elymus triticoides, seeds, fiber	5	10
Sporobolus asperifolius, seeds		1
Panicum capillare, seeds	1	
Phragmites communis, fiber		2
Eleocharis cf. *palustris*, seeds		2
Scirpus robustus, achenes, fiber	19	30
Scirpus sp., achenes, tuber	0	1
Juncus sp., seeds, fiber	0	1
Rumex cf. *utahensis*, seeds	0	2
Atriplex sp., seeds	5	8
Salsola cf. *kali*, pollen	1	0
Suaeda sp., seeds, fiber	6	2
Amaranthus sp., seeds, pollen	0	2
Stellaria sp., seeds	1	2
Chaenactus sp., seeds	0	1
Mentzelia gracilis, seeds	0	1
Unidentified plant remains		
Charcoal	9	13
Twigs	2	1
Pollen	1	3
Roots	0	1
Tubers	5	1
Stem, leaves	18	27
Animal		
Mollusks		
Gyraulus sp., shell	3	6
Stagnicola sp., shell	1	2
Insects		
Anthrenus sp., body parts	7	11
Ptinus sp., body parts	2	6
Fish		
Catostomus tahoensis, scales, bones	1	1
Gila (=*Siphateles*) *bicolor*, scales, bones	13	15
Rhinichthys osculus robustus, scales, bones	4	0
Birds		
Colymbus sp., feathers	2	0
Pelecanus cf. *erythrorhynchos*, feathers	1	0
Nycticorax sp., feathers	1	0
Chen hyperborea, feathers	1	0
Anas sp., feathers, bones	1	0
Nyroca cf. *valisineria*, feathers	1	0
Fulica americana, feathers, bones	7	0
Mammals		
Ursus americanus, hair	0	1
Bassaricus astutus nevadensis, hair	0	3
Canis latrans, hair	1	4
Citellus sp., hair	0	1
Eutamias sp., hair	0	1
Peromyscus cf. *maniculatus*, hair	1	0
Lepus cf. *americanus*, hair, bone	1	0
Sylvilagus sp., hair	1	0
Odocoileus hemionus, hair	1	2
Antilocapra americana, hair	1	0
Ovis canadensis, hair	1	0
Human		
Homo sapiens, hair	6	7

squirrel, and bighorn sheep, and a considerable amount of human hair. Brunetti (*42*) identified feathers, fragments of bird skin, and other avian remains representing coots (*Fulica americana americana*), ducks (*Anas*), and other waterfowl (*43*).

These and other detailed analyses performed by scientists representing more than three dozen separate fields of study have revealed many aspects of the dietary practices of the prehistoric inhabitants of Lovelock Cave (see Table 1). Much less has been accomplished in the way of investigating the "biomedical" properties of the Lovelock coprolites. Tubbs and Berger (*36*) examined two Lovelock coprolites for viable pathogens, but no organisms could be cultured. This finding is consistent with results obtained by Sneath, whose study material included 3500-year-old human fecal material from Mexico (*48*). Dunn of the Hooper Foundation, University of California Medical Center, San Francisco, examined approximately 50 coprolites for the presence of human parasites, but found none (*49*). Helminths (larval nematodes of the genus *Rhabditis*) were preserved, however, indicating that parasitological material can survive in ancient fecal material, a conclusion consistent with the findings of other workers (*50*). The apparent absence of human endoparasites in the Lovelock coprolites can be taken to indicate that the Lovelock human population was free of these organisms (*49*), but, in order to verify this conclusion, it would be desirable to examine the visceral contents of some of the desiccated human remains found in the cave in 1912 and 1924. An amorphous mass of human fecal matter found in the cave contained Charcot-Leyden crystals, such as are commonly observed in modern dysenteric or diarrheal feces, particularly in association with intestinal amebiasis resulting from infection by *Entamoeba histolytica.*

Conclusions

Coprolite analysis is the most precise method available to archeologists for determining ancient dietary patterns and food-preparation practices. Human coprolites have been examined for parasites, pollens, and macroconstituents, but there has been almost no examination of fecal material by pathologists, students of communicable or deficiency diseases, or individuals interested in prehistoric human sanitation and other related fields. The Lovelock collections maintained at the University of California, Berkeley, include desiccated human remains in a good state of preservation and more than 5000 specimens of excrement produced by the prehistoric residents of the cave. This uniquely preserved biological material can be used to carry out research in fields such as palynology, ethnobotany, pathology, nutrition, physiology, environmental sanitation, epidemiology, and forensic medicine (*51*). Intensive analysis, by workers in the biological and physical sciences, of coprolites found in Lovelock Cave can form the basis of a major contribution to scientific investigation of the prehistoric Indian populations of the American Great Basin region.

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51. The abundance of the coprolites permits us to offer to provide interested persons with samples of the ancient human fecal material from Lovelock Cave. We welcome inquiries and correspondence concerning the coprolites, human remains, vegetal matter, feathers, and other biological material that has been recovered from the cave.
52. Acknowledgements are made to S. Elberg, dean of the Graduate Division, University of California, Berkeley; the Wenner-Gren Foundation for Anthropological Research; the National Science Foundation (grant GS-2297); Dr. G. H. Stopps, assistant director of the Haskell Laboratory, E. I. du Pont de Nemours & Company; the Archaeological Research Facility; and the department of anthropology, University of California, Berkeley, for financial support during the period 1965–68. We are indebted to many specialists for identification of coprolite components or for radiocarbon dating, and we wish to thank all of them, in particular Dr. Rainer Berger, Institute of Geophysics and Interplanetary Physics, University of California, Los Angeles, and Dr. W. I. Follett, California Academy of Sciences.

NEWS AND COMMENT

Forest Fires: Suppression Policy Has Its Ecological Drawbacks

Careless outdoorsmen and a dry spring in interior Alaska have combined to produce the most severe forest fire season of the decade in the 49th state. The U.S. Bureau of Land Management (BLM), the government agency that supervises most of Alaska's real estate, estimates that this summer's fires have blackened over 4.2 million acres of forest, an area larger than the state of Connecticut. BLM has thrown helicopters, fire-retardant bombers, infrared detection systems, and up to 1700 men into the battle to suppress the fires, but the Bureau has decided to defend only villages and other valuable sites, letting the hinterland forests burn over, as they have for centuries.

For many Alaskans this BLM decision to let some wilderness fires burn unopposed represents a failure that improved technology should eventually remedy. But many ecologists now suggest that forest fires such as these may well be a desirable way to maintain important ecological relationships. In the lower 48 states, some foresters are also having second thoughts about the policy of absolute fire suppression that has dominated the conservation movement since its early days. Federal and state agencies spend large sums ($186 million in fiscal 1968) to suppress forest fires, yet an average of 4.8 million acres still burn each year. The philosophy symbolized by Smokey the Bear—the cartoon emblem of the nation's fire-fighting campaign—has proved successful in many areas, but this very success has generated its own set of problems. Without periodic fires to remove underbrush and decaying leaf matter from the forest floor, many woodlands have experienced marked ecological changes and have become far more vulnerable to wildfire than they were before the white man intervened.

To limit these side effects of fire suppression, foresters in many areas now deliberately set forests afire under controlled conditions. In 1967, government and private land owners removed an estimated 61 million tons of excess fuel in controlled burning operations on 2.9 million acres of land.

This shift in forest-management policy has slowly gained support among foresters over the last 30 years as the forestry profession reexamined its fundamentalist crusade against forest fires in general. The early fire crusaders had focused chiefly on fire's drawbacks: